Leo F. King

BULLETIN OF UNDERGRADUATE STUDIES

1977-1979

COLLEGE OF ENGINEERING

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BULLETIN OF UNDERGRADUATE STUDIES

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Prospective applicants for admission will find it helpful to first refer to sections of the *Admissions Regulations and General Academic Rules* regarding policies of the University and then refer to this bulletin for details concerning specific curricula and course offerings.

The rules and regulations published in this bulletin were in effect at the beginning of the 1976-1977 academic year and are subject to change through established procedures of the College of Engineering. Changes in academic rules and regulations are effective at the beginning of the academic year following their adoption. Listings of course offerings are subject to change by concerned departments and University administrators in the event that unforseen faculty changes have taken place or insufficient numbers of students have subscribed to course offerings. The official schedule of course offerings for each semester is provided in the *Schedule of Classes,* which is published biannually by the Office of the Registrar.

The University of Lowell is an Equal-Employment, Affirmative-Action University and does not discriminate in admissions or employment on the basis of sex in compliance with Title IX. Any inquiries concerning Title IX should be directed to the Title IX Coordinator or the Director of the Office of Civil Rights.

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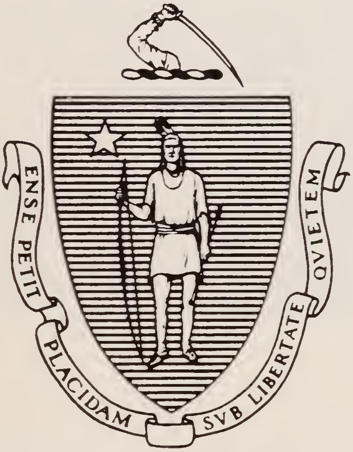

COLLEGE OF ENGINEERING

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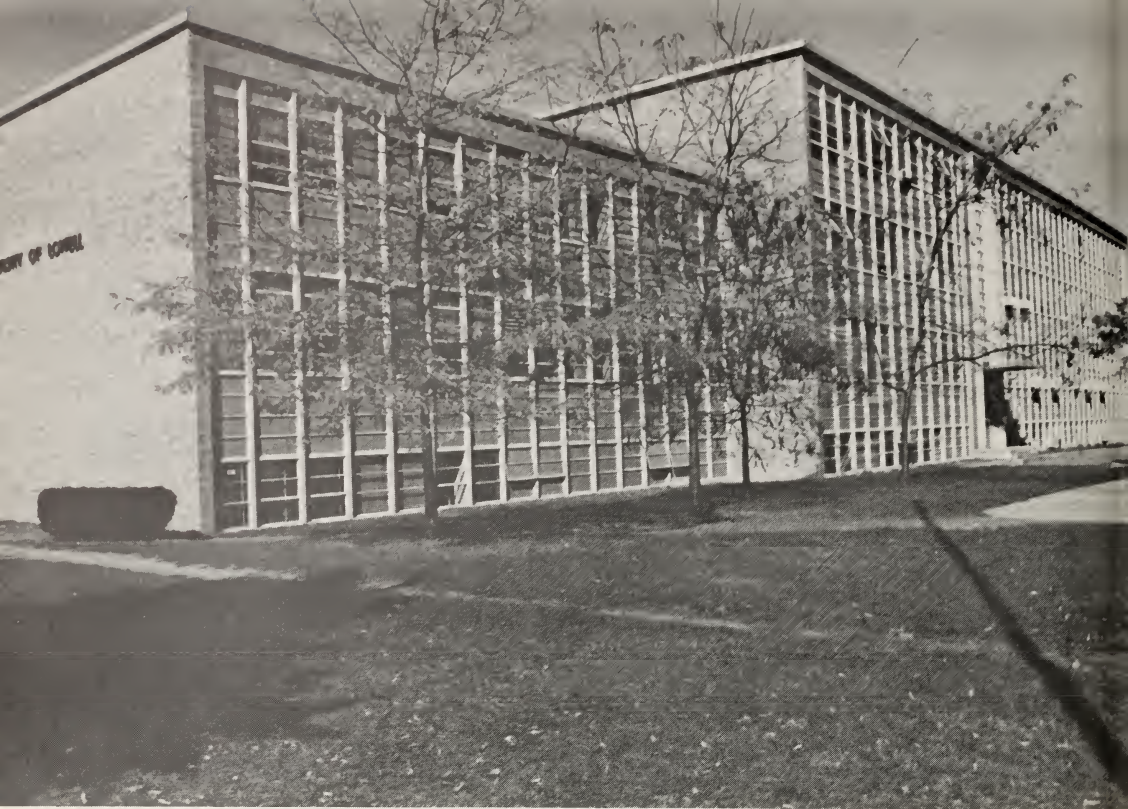
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TABLE OF CONTENTS

Academic Policies

Undergraduate Engineering Education 2
Objectives of the College of Engineering 2
Baccalaureate Degree Programs 2
    Chemical Engineering 3
    Civil Engineering 6
    Electrical Engineering 8
    Industrial Technology 11
    Mechanical Engineering 13
    Nuclear Engineering 16
    Plastics Engineering 18
General College Requirements 21
    Residency Requirement 21
    Attendance Requirement 21
    Declaration of Program 21
    Change of Program 22
    Transfer Policies 22
    Repetition of Transfer Courses at the University 23
    Intercollegiate Transfer within the University 23
    Curriculum Requirements for the Graduating Classes of 1977 and 1978 . 23

Course Descriptions

Course Prefixes 25
Course Numbers 25
Semester, Class, and Credit Designations 25
Course Restrictions 26
Instructor Designations 26
Department Course Offerings 27
    Chemical Engineering 27
    Civil Engineering 32
    Electrical Engineering 36
    Industrial Technology 47
    Mechanical Engineering 49
    Nuclear Engineering 57
    Plastics Engineering 60

College Organization and Governance 66

Faculty of the College 68

COLLEGE OF ENGINEERING

ACADEMIC POLICIES

UNDERGRADUATE ENGINEERING EDUCATION

Broadly defined, engineering is a profession which seeks to apply scientific knowledge for the improvement of society. Because of the vastly varied needs of society and differences in individual talent and motivation, a wide spectrum of engineering education programs have been developed in the United States. In order to best serve the needs of its student body the College of Engineering offers programs distributed within this spectrum. Although the emphasis within each program is specific and technical, each program has the educational breadth that distinguishes the professional.

The engineer must be able to identify problems, creatively design solutions, build and implement. In the practice of the profession, the engineer will be called on to combine knowledge of science, mathematics, and "state of the art" with judgement based on experience in order to develop economic and socially acceptable ways to use the available resources for the benefit of mankind. The professional is constantly searching for a better way, a better design, a more imaginative and effective system.

OBJECTIVES OF THE COLLEGE OF ENGINEERING

The educational objective of the College of Engineering is to prepare students for entrance into the profession of engineering. In recognition of the variety of professional activities involved, the programs have been designed to allow students to elect to enter the practice of engineering after completion of an undergraduate degree or to delay entrance until thay have obtained a graduate degree. Faculty advisors are assigned to each student in order to provide experienced guidance to the student in the selection of his particular program.

BACCALAUREATE DEGREE PROGRAMS

The College of Engineering offers undergraduate programs leading to a Bachelor of Science degree in chemical engineering, civil engineering, electrical engineering, mechanical engineering, nuclear engineering, plastics engineering, and industrial technology. For details concerning graduate engineering programs, see the *Graduate School Catalogue.*

The Bachelor of Science degree is designed to provide students with a specialized education in one or more of the basic sciences and in technological or engineering fields. Bachelor of Science degree programs generally have been determined by the requirements of specific career objectives and often are subject to the recommendations of professional associations. Course requirements for such professional programs as engineering are specified in terms of fixed curricula and without reference to minor requirements.

The requirements of majors are set by University departments or interdisciplinary committees but must specify a minimum of 30 semester credits. At least 15 credits in the major field must be taken at the upper-division course level.

Chemical Engineering

Chemical engineering is a broad-based engineering discipline. It is the only engineering discipline based on the science of chemistry. It concerns itself primarily with chemical reactions, reaction kinetics, and equilibria and mass and energy transport. Chemical engineers have traditionally entered the chemical and allied industries in all phases of the business.

More recently, the broad background of the chemical engineer has allowed him to move into many other fields such as management, environmental protection, bio-chemical engineering, petrochemicals, polymer science, enzyme engineering and patent law. Many chemical engineers even start their own businesses.

The basic concepts of unit operations and unit processes originally developed by chemical engineers, have proved to be effective over a wide spectrum of applications. The chemical process industry and its allied industries such as paper, plastics, packaging, environmental protection, pharmaceuticals, materials science, and the like, have provided a strong and continuing growth for chemical engineering graduates.

The stability and dynamic growth of the industries cited have opened unparralleled challenges for growth for the graduate trained in this discipline. The paper industry is the fifth largest industry in the United States. The importance of this industry is recognized. This department provides the student the choice to elect a block of technical electives which comprise an option in paper engineering. A large number of scholarships ($500 per year) are available to students who elect this option.

The chemical engineering curriculum provides maximum flexibility and allows the individual to do original research. Considerable emphasis is placed on oral and written reports to provide a necessary background for the business world. Plant trips provide the essential link between theory and practice. Summer jobs in the chemical industry and the paper industry are encouraged. A number of scholarships are available to undergraduates.

This broad chemical and engineering training allows the graduate to enter research and development, product or process development, production, sales, marketing and general management. He is well prepared to enter graduate programs in the discipline or in the master of business administration. This Chemical Engineering curriculum is accredited by the Engineers' Council for Professional Development.

COURSES OF STUDY FOR CHEMICAL ENGINEERING

Freshman Year

Fall Semester

84-121*	Chemistry	3
84-123*	Chemistry Lab	1
42-101	College Writing	3
92-131	Calculus B-I	
or		
92-133	Calculus A-I	4
95-141*	Introductory Physics	3
96-141*	Fundamentals of Experimental Physics I	1
	Physical Education	
		15

*84-135 Honors Chemistry and, 84-137 Honors Chemistry Lab, 95-147 Honors Physics and, 96-147 Fundamentals of Experimental Physics I may be substituted.

Spring Semester

84-126*	Chemistry	3
84-124*	Chemistry Lab	1
42-102	College Writing & Literature	3
92-132	Calculus B-II	
or		
92-134	Calculus A-II	4
95-144*	Fundamentals of Physics I	3
96-144*	Fund. of Exp. Physics II	1
	Physical Education	
		15

*84-136 Honors Chemistry and, 84-138 Honors Chemistry Lab, 95-148 Honors Physics and, 96-148 Fundamentals of Experimental Physics II may be substituted.

Sophomore Year

Fall Semester

84-223	Organic Chemistry	4
10-203	Intro. to Chem. Eng.	3
10-207	Comp. Prog. for Chem. Eng.	1
92-231	Calculus B-III	4
or		
92-233	Calculus A-III	3
22-201	Graphics	1
22-215	Analytic Mechanics I	3
64-201	Economics I	3
		18-19

Spring Semester

84-224	Organic Chemistry	3
10-204	Chem. Eng. Calculations	3
10-206	Fluid Mechanics	2
10-208	Unit Operations Lab. I	1
92-232	Calculus B-IV	4
or		
92-234	Calculus A-IV	3
22-216	Analytic Mechanics II	3
64-202	Economics II	3
		18-19

Junior Year

Fall Semester

10-305	Heat Transfer	3
10-311	Chem. Eng. Thermodynamics	3
10-315	Unit Operation Lab. II	1
16-348	Electrical Eng. Concepts	3
92-301	Advanced Calculus for Applications	3
	Humanistic - Social Elective	3
		16

Spring Semester

84-336	Principles of Physical Chemistry	3
84-338	Principles of Physical Chemistry Lab.	1
10-306	Transport Phenomena	3
10-308	Engineering Materials	3
10-310	Separation Processes	3
10-316	Unit Operations Lab. III	1
	Humanistic - Social Elective	3
		17

Senior Year

Fall Semester

10-403	Reactor Design and Kinetics	3
10-409	Economics & Process Analysis	3
10-413	Process Dynamics and Control	3
	Technical Elective	3
	Undesignated Elective*	3
	Humanistic - Social Elective	3
		18

*ROTC Students may elect 29-401

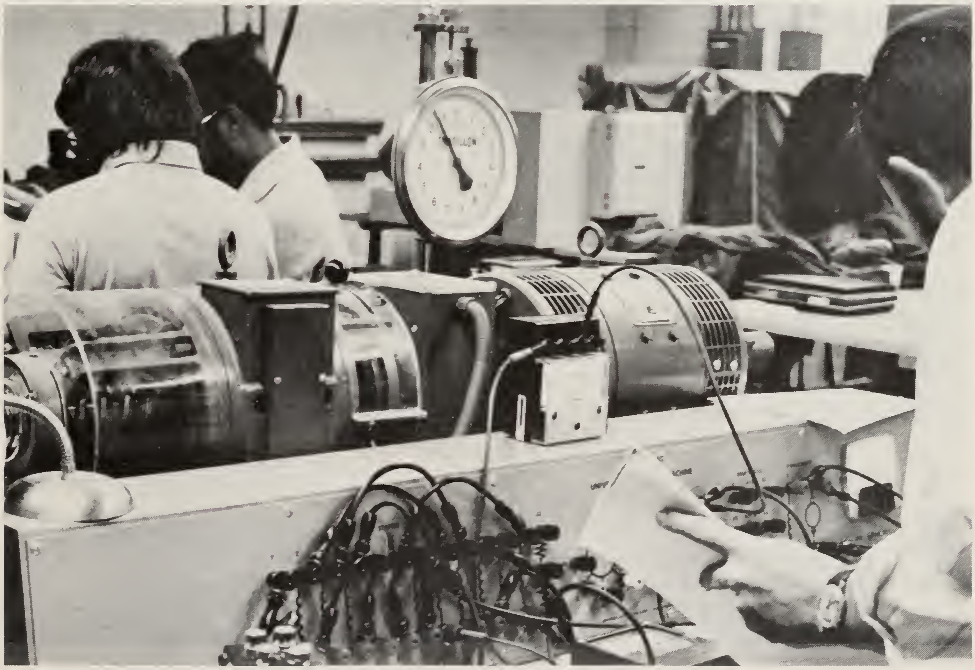
Spring Semester

10-410	Plant Design	3
10-416	Process Dynamics and Control Lab.	2
	Technical Elective	3
	Undesignated Elective*	3
	Humanistic - Social Elective	3
	Humanistic - Social Elective	3
		17

*ROTC Students may elect 29-402

Students electing the Option in Paper Engineering will take the following courses in their Senior Year as Technical Electives:

10-401	Paper Industry Process Analysis	3
10-402	Eng. Anal. of Coating & Converting Systems	3
10-404	Process Cal. of Pulp & Paper Processes	3
10-405	Design of Papers	4
10-419	Special Projects	1



Civil Engineering

Civil engineering is that branch of engineering charged with the planning, design, construction and operation of works vital to man's activities in his relation to the environment. The concerns of the civil engineer include the gathering and processing of environmental information; avenues of transportation; facilities and structures to accommodate domestic, business, industrial, scientific, and recreational pursuits; the control and management of the forces of nature as such affect the environment; the treatment and disposal of solid, liquid and aerial waste; and the adaption of materials, natural or man-made, to the works under his control.

Because of the broad range of the civil engineer's activities, this curriculum is based on a breadth of scientific and engineering principles. Such fundamentals are then expanded into specialized subjects to provide a comprehensive and basic training in the responsibilities of the civil engineer.

Graduates of civil engineering are prepared to apply their training to highways, railroads, airports, pipelines and waterways; bridges, dams, canals and levees; filtration plants and distribution systems for municipal and industrial water supplies along with sewage and waste treatment plants to protect health. Also in their province are civil engineering aspects of high-rise buildings, power plants, industrial, military and space facilities. After advanced training, the areas of research and teaching are open to them.

COURSES OF STUDY FOR CIVIL ENGINEERING

Freshman Year

Fall Semester			Spring Semester		
42-101	College Writing	3	42-102	College Writing & Literature	3
84-121*	Chemistry	3	84-126*	Chemistry	3
84-123*	Chemistry Lab	1	84-124*	Chemistry Lab	1
92-131	Calculus B-I		92-132	Calculus B-II	
or			or		
92-133	Calculus A-I	4	92-134	Calculus A-II	4
95-141*	Introductory Physics	3	95-144*	Fundamentals of Physics I	3
96-141*	Fund. of Exp. Physics I	1	96-144*	Fund. of Exp. Physics II	1
	Physical Education			Physical Education	
		15			15

*84-135 Honors Chemistry and, 84-137 Honors Chemistry Lab, 95-147 Honors Physics and, 96-147 Fundamentals of Experimental Physics I may be substituted.

*84-136 Honors Chemistry and, 84-138 Honors Chemistry Lab, 95-148 Honors Physics and, 96-148 Fundamentals of Experimental Physics II may be substituted.

Sophomore Year

Fall Semester

14-203	Statics	3
14-220	Surveying I	4
14-223	Graphics	1
92-231	Calculus B-III	4
or		
92-233	Calculus A-III	3
92-361	Digital Computer Programming	2
	Humanistic - Social Elective	3
		16 or 17

Spring Semester

14-204	Strength of Materials	3
14-221	Surveying II	4
42-112	Tech. & Scientific Comm.	3
92-232	Calculus B-IV	4
or		
92-234	Calculus A-IV	3
	Numerical Analysis	3
		16 or 17

Junior Year

Fall Semester

14-310	Engineering Materials	3
14-350	Structural Analysis	4
22-309	Dynamics I	3
64-201	Economics I	3
	Humanistic - Social Elective	3
		16

Spring Semester

14-301	Fluid Mechanics	3
14-340	Transportation	4
14-351	Structural Design I	4
22-347	Elements of Thermodynamics & Heat Transfer	3
64-202	Economic II	3
		17

Senior Year

Fall Semester

14-430	Soil Mechanics I	3
14-460	Water Resources Engineering	3
16-348	Basic Electrical Engineering Concepts	3
	Humanistic - Social Elective	3
	Humanistic - Social Elective	3
	Undesignated Elective*	3
		18

*ROTC Students may elect 29-401

Spring Semester

14-431	Foundation & Soil Eng.	3
14-461	Water Resources Designs	2
16-214	Electrical Machinery Lab.	1
92-414	Math. Methods in Engineering Management	3
	Humanistic Social Elective	3
	Undesignated Elective*	3
		15

*ROTC Students may elect 29-402

Electrical Engineering

The objectives of this curriculum is to provide the student with a sound foundation for a professional career in electrical engineering. The degree awarded after four years of study is a Bachelor of Science in Electrical Engineering.

Electrical engineering is a dynamic field, receiving much of its stimulus from contemporary breakthroughs in the pure sciences. Because new concepts and developments are continuously entering the engineering disciplines, the viable engineering education cannot be limited to the acquisition of specific skills and methods but must provide the student with a deep understanding of his field, while anticipating his future needs.

Hence, students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classrooms. Specialization at the undergraduate level is, in general, discouraged. Interdisciplinary study is fostered by a relatively flexible elective system.

An important aspect of the electrical engineering curriculum is the technical elective program of the senior year. Technical electives provide opportunities for broadening or deepening technical knowledge in a flexible manner and in accordance with student interests and competencies. Normally, such electives are senior-level electrical engineering courses. However, courses in scientific subjects may be taken from the offerings of the College of Engineering or the College of Pure and Applied Sciences up to a maximum of 6 credits when approved by the academic advisor. Approval of such scientific courses is ordinarily granted when their technical content is more advanced than that of required courses in the same areas.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of nontechnical knowledge in determining the student's ultimate level of responsibility in professional life.

Many of the courses required in the electrical engineering curriculum are heavily dependent upon mathemetical techniques. It is therefore recommended that a freshman seeking admission into the sophomore year in electrical engineering should have received grades of not less than "C" in all freshman mathematics and physics. This curriculum is accredited by the Engineer's Council for Profession Development.

COURSES OF STUDY FOR ELECTRICAL ENGINEERING

Freshman Year

Fall Semester

84-121*	Chemistry	3
84-123*	Chemistry Lab	1
42-101	College Writing	3
92-131	Calculus B-I	
or		
92-133	Calculus A-I	4
95-141*	Introductory Physics	3
96-141*	Fundamentals of Exp. Physics I	1
	Physical Education	
		15

*84-135 Honors Chemistry and, 84-137 Honors Chemistry Lab, 95-147 Honors Physics and, 96-147 Fund. of Experimental Physics I may be substituted.

Spring Semester

84-126*	Chemistry	3
84-124*	Chemistry Lab	1
42-102	College Writing & Literature	3
92-132	Calculus B-II	
or		
92-134	Calculus A-II	4
95-144*	Fundamentals of Physics I	3
96-144*	Fund. of Exp. Physics II	1
	Physical Education	
		15

*84-136 Honors Chemistry and, 84-138 Honors Chemistry Lab, 95-148 Honors Physics and, 96-148 Fund. of Experimental Physics II may be substituted.

Sophomore Year

Fall Semester

64-201	Economics I	3
16-201	Introductory Circuit Theory I	4
16-207	Basic Elec. Eng. Lab. I	2
16-227	Intro. Computer Programming	1
92-231	Calculus B-III	4
or		
92-233	Calculus A-III	3
95-245	Fundamentals of Physics II	3
96-245	Fund. of Exp. Physics III	1
		17 or 18

Spring Semester

64-202	Economics II	3
16-202	Intro. Circuit Theory II	4
16-208	Basic Elec. Eng. Lab. II	2
16-228	Prog. & App. of Digital Comp.	3
92-232	Calculus B-IV	4
or		
92-234	Calculus A-IV	3
		15 or 16

Junior Year

Fall Semester

16-311	Electronics Laboratory I	2
16-355	Intro. Electromechanics	3
or		
16-362	Signal and System Analysis	3
16-365	Electronics I	3
92-315	Complex Variables for Eng.	3
	Humanistic - Social Elective	3
	Humanistic - Social Elective	3
		17

Spring Semester

16-312	Electronics Laboratory II	2
16-360	Electromagnetic Theory I	3
16-362	Signal and System Analysis	3
or		
16-355	Introductory Electromechanics	3
16-366	Electronics II	3
22-212	Introductory Mechanics	4
	Humanistic - Social Elective	3
		18

Senior Year

Fall Semester

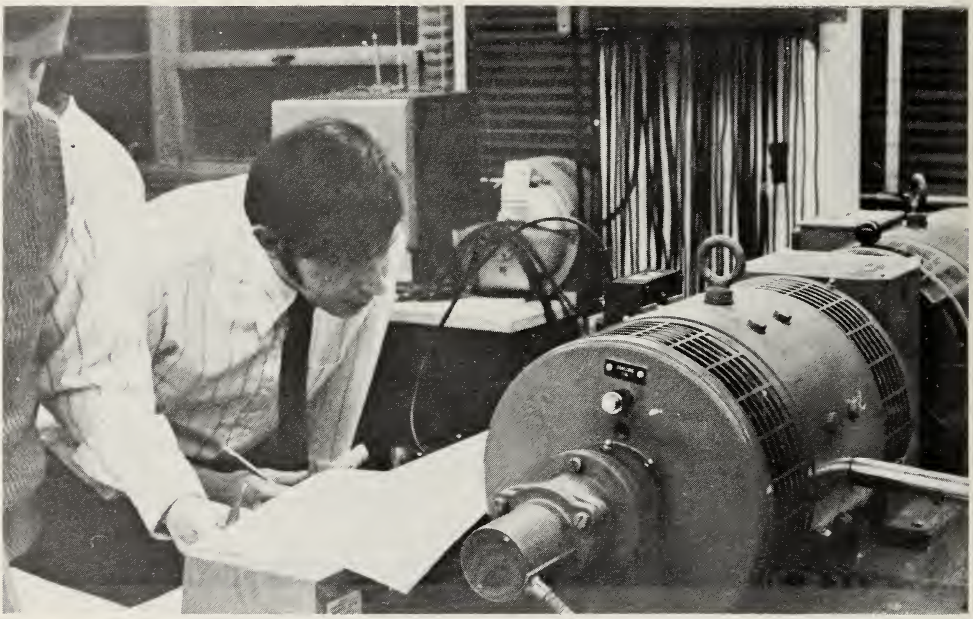
16-413	Linear Feedback Systems	3
or	Technical Elective	3
16-461	Electromagnetic Theory II	3
22-347	Elements or Thermodynamics & Heat Transfer	3
	Undesignated Elective*	3
	Humanistic - Social Elective	3
		15

*ROTC Students may elect 29-401

Spring Semester

	Technical Elective	3
or		
16-413	Linear Feedback Systems	3
	Technical Electives	6
	Undesignated Elective*	3
	Humanistic - Social Elective	3
		15

*ROTC Students may elect 29-402 for three hours.



Industrial Technology

The recently established industrial technology program is designed to increase the variety of educational opportunities available to undergraduate students. The program's objective is to prepare students for professional careers in the rapidly expanding fields of production, manufacturing and institutional systems. Their careers will emcompass a broad band of activities touching on the one extreme, the engineering sciences and on the other, business administration.

The industrial technology graduate, drawing on both his theoretical knowledge and his industrial skills, will be in a position to direct manufacturing operations, to establish and supervise production procedures, to supervise the flow of supplies and products, and in general to cope with technical and managerial aspects of modern industry and institutions. The majority of graduates enter directly into industry. A small but significant number pursue graduate study in such fields as manufacturing engineering, industrial education, business administration, health care and delivery systems.

A significant feature of this new program is the possibility to incorporate - for academic credit - supervised industrial experience. This together with the theoretical and applied background provided by the University will make the graduate flexible and capable of adapting to a wide variety of industrial organizations and problems.

The curriculum is a carefully organized interdisciplinary program providing a well-balanced education. Approximately forty percent of the curriculum pertains to technical subjects such as measurements, numerical and automatic controls, manufacturing processes and operations; twenty percent of the curriculum consists of business subjects; another twenty percent relates to the social sciences and humanities. The balance lies in the mathematics and science areas. Sufficient electives are provided to permit students to fully round out their primary interest or pursue their career goals.

Because the students in industrial technology aspire to a large variety of professional goals, a flexible transfer credit policy is maintained. A student without transfer credit or advanced standing will take an average of 16 credits per semester.

COURSES OF STUDY FOR INDUSTRIAL TECHNOLOGY

Freshman Year

Fall Semester

84-111	General Chemistry	4
64-201	Economics I	3
42-101	College Writing	3
92-101	Math. Analysis I	3
20-105	Intro. To Mechanical Design	3
	Physical Education	
		16

Spring Semester

42-102	College Writing & Literature	3
92-102	Math. Analysis II	3
95-151	General Physics	4
	Humanistic - Social Elective	3
20-171	Machine Tool Laboratory	3
	Physical Education	
		16

Sophomore Year

Fall Semester

60-201	Accounting Principles I	3
42-112	Tech. & Scientific Comm.	3
92-201	Math Analysis III	3
20-201	Structure of Metals	3
20-204	Mechanics for Technology	4
		16

Spring Semester

60-202	Accounting Principles II	3
92-383	Statistics	3
20-202	Industrial Computer Science	3
20-203	Mech. Power Transmission	4
26-211	Plastics	3
		16

Junior Year

Fall Semester

20-308	Fluid Power Controls	3
66-321	Marketing Principles	3
66-371	Operation Management I	3
16-901	Intro. to Ind. Electricity	4
	Humanistic - Social Elective	3
		16

Spring Semester

20-301	Modern Material	3
20-305	Manufacturing Processes	3
66-372	Operation Management II	3
or		
20-306	Seminar I	
74-101	Psychology	3
	Humanistic - Social Elective	3
		15

Senior Year

Fall Semester

20-408	Instrumentation & Process Control	4
20-414	Engineering Economy	3
20-476	Statistical Quality Control	3
20-403	Seminar II	3
or	Elective* (in the fields of Engineering, Science and Management Science)	
	Humanistic - Social Elective	3
		16

*ROTC Students may Substitute 29-401

Spring Semester

20-402	Manufacturing Operations	3
20-406	Seminar III	
or		
	Technical Elective	3
66-452	Industrial Relations	3
	Humanistic - Social Elective	3
	Undesignated Elective*	3
		15

*ROTC Students may Substitute 29-402

Mechanical Engineering

Mechanical engineering is a diversified professional activity. The mechanical engineer is called upon to develop new methods of energy production and conversion, transportation, manufacture, and fabrication.

Because of the diversification of mechanical engineering, it is not possible for a student to master the entire field during a four year program. The objective of this curriculum is to provide a broad fundamental base from which the graduate can go on to develop his skills by either entering general engineering practice or pursuing an advanced engineering degree. The curriculum is designed to achieve this objective by means of a three phase program.

The first phase consists of acquiring a background in humanistic-social studies, and the basic sciences. The purpose of the first phase is to broaden the student's outlook and provide a firm understanding of fundamentals, develop analytical techniques, and to prepare for specific technical subjects.

The second phase consists of acquiring a knowledge in a coherent area of engineering science. The purpose of this phase is to form the link between the basic sciences and engineering, and to introduce the methodology of engineering analysis, design and synthesis. Three areas of engineering science have been selected for this phase; namely, solid mechanics (statics, dynamics and mechanics of materials), thermaltransport (thermodynamics, fluid mechanics and heat transfer), and dynamic systems (electricity, electronics, systems and controls).

In the final phase of the curriculum, advanced problems and topics are considered in engineering design. The purpose of the design activity is to develop skill in the use of science and creativity to solve engineering problems and thus requires the utilization of the first two phases.

A variety of laboratory work is included in the curriculum in order to demonstrate the use of the experimental method in the solution of engineering problems. To permit a degree of specialization, technical electives are provided. A staff advisor system is used inorder to aid the student in selecting technical electives so that the subjects will be consistent with the future career plans of the student. This curriculum is accredited by the Engineers' Council for Professional Development.

COURSES OF STUDY FOR MECHANICAL ENGINEERING

Freshman Year

Fall Semester

84-121*	Chemistry	3
84-123*	Chemistry Lab	1
42-101	College Writing	3
92-131	Calculus B-I	
or		
92-133	Calculus A-I	4
95-141*	Introductory Physics	3
96-141*	Fund of Exp. Physics I	1
	Physical Education	
		15

*84-135 Honors Chemistry and, 84-137 Honors Chemistry Lab
95-147 Honors Physics and, 96-147 Fund. of Experimental Physics I may be substituted.

Spring Semester

84-126*	Chemistry	3
84-124*	Chemistry Lab	1
42-102	College Writing & Literature	3
92-132	Calculus B-II	
or		
92-134	Calculus A-II	4
95-144*	Fundamentals of Physics I	3
96-144*	Fund. of Exp. Physics II	1
	Physical Education	
		15

*84-136 Honors Chemistry and, 84-138 Honors Chemistry Lab.
95-148 Honors Physics and, 96-148 Fund. of Experimental Physics II may be substituted.

Sophomore Year

Fall Semester

16-211	Fundamentals of Elec.	3
92-231	Calculus B-III	4
or		
92-233	Calculus A-III	3
92-361	Digital Computer Programming	2
22-271	Machine Tool Laboratory	1
22-211	Mechanics I	3
95-245	Fundamentals of Physics II	3
96-245	Fund. of Exp. Physics III Lab.	1
		16 or 17

Spring Semester

16-212	Introductory Electronics	3
92-232	Calculus B-IV	4
or		
92-234	Calculus A-IV	3
22-205	Intro. to Mechanical Design	3
22-206	Mech. Engineering Lab. I	1
22-220	Mechanics of Materials I	3
22-242	Thermodynamics	3
	Humanistic Social Elective	3
		19 or 20

Junior Year

Fall Semester

64-201	Economics I	3
92-301	Adv. Calculus for Applications	3
22-307	Mech. Engineering Lab. II	1
22-309	Dynamics I	3
22-382	Fluid Mechanics	3
22-395	Materials Science	3
		16

Spring Semester

64-202	Economics II	3
22-308	Mech. Engineering Lab. III	1
22-320	Mechine Design I	3
22-343	Heat Transfer	3
22-354	Dynamics Systems	3
	Humanistic - Social Elective	3
		16

Senior Year

Fall Semester

22-407	Mechanical Eng. Lab. IV	1
22-409	Senior Project I	1
22-474	Thermodynamics Applications	3
22-497	Automatic Control Systems	3
	Humanistic - Social Elective	3
	Technical Elective	3
	Undesignated Elective*	3
		17

*ROTC Students may elect 29-401

Spring Semester

22-410	Senior Project II	2
	Technical Elective	3
	Technical Elective	3
	Humanistic - Social Elective	3
	Humanistic - Social Elective	3
	Undesignated Elective*	3
		17

*ROTC Students may elect 29-402

One of the technical electives must be in the design area.

Nuclear Engineering

The nuclear engineering course was the first course of its kind taught in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

Sufficient social science and humanities electives are required to insure that the student's experience is not confined to technological training, but, rather, will lead to a well-educated individual. The requirement for three technical electives and two undesignated electives also gives the student an opportunity to focus his interests in a specific area such as materials science, reactor physics, electric power systems, etc., and such areas of concentration are recommended.

A colloquium is sponsored jointly by the Departments of Nuclear Engineering and Radiological Sciences. Invited speakers present lectures on a variety of technical and research topics of current interest in nuclear science and engineering. All students are encouraged to attend.

COURSES OF STUDY FOR NUCLEAR ENGINEERING

Freshman Year

Fall Semester

84-121*	Chemistry	3
84-123*	Chemistry Lab	1
42-101	College Writing	3
92-131	Calculus B-I	
or		
92-133	Calculus A-I	4
95-141*	Introductory Physics	3
96-141*	Fundamentals of Exp. Physics I	1
	Physical Education	
		15

Spring Semester

84-126*	Chemistry	3
84-124*	Chemistry Laboratory	1
42-102	College Writing & Lit.	3
92-132	Calculus B-II	
or		
92-134	Calculus A-II	4
95-144*	Fund. of Physics I	3
96-144*	Fund. of Exp. Physics II	1
		15

*84-135 Honors Chemistry and, 84-137 Honors Chemistry Lab.
95-147 Honors Physics and, 96-147 Fund. of Experimental Physics I may be substituted.

*84-136 Honors Chemistry and, 84-138 Honors Chemistry Lab.
95-148 Honors Physics and, 96-148 Fund. of Experimental Physics II may be substituted.

Sophomore Year

Fall Semester

22-201	Graphics	1
16-211	Fundamentals of Electricity	3
92-231	Calculus B-III	4
or		
92-233	Calculus A-III	3
80-201	Physics of Radiation	3
95-245	Fundamental of Physics II	3
96-245	Fund. of Exp. Physics Lab. III	1
	Humanistic - Social Elective	3
		17 or 18

Spring Semester

24-204	Seminar in Nuclear Eng.	1
92-232	Calculus B-IV	4
or		
92-234	Calculus A-IV	3
80-202	Physics of Nuclei	3
80-206	Nuclear Instrumentation I	4
22-228	Mechanics of Deformable Bodies	4
	Humanistic - Social Elective	3
		18 or 19

Junior Year

Fall Semester

92-301	Adv. Calculus for Appl.	3
22-242	Thermodynamics	3
24-301	Reactor Physics I	3
80-305	Nuclear Instrumentation II	4
64-201	Economics I	3
	Humanistic - Social Elective	3
		19

Spring Semester

92-302	Adv. Calculus for Appl.	3
22-382	Fluid Mechanics I	3
24-302	Reactor Physics I	3
64-202	Economics II	3
80-397	Computer Programming & Applications I	3
	Humanistic - Social Elective	3
		18

Senior Year

Fall Semester

22-343	Heat Transfer	3
24-401	Nuclear Reactor Eng. I	3
	Technical Elective	3
	Humanistic - Social Elective	3
	Undesignated Elective*	3
		15

*ROTC Students may substitute 29-401

Spring Semester

24-402	Nuclear Reactor Eng. II	3
	Technical Elective	3
	Technical Elective	3
	Technical Elective	3
	Undesignated Elective*	3
		15

*ROTC Students may substitute 29-402

Plastics Engineering

Plastics engineering is a specialized body of knowledge concerned with the synthesis of polymeric materials and their conversion to useful end products. It is the practical application of principles of mathematics, physics, chemistry, engineering and economics to the field of high polymers.

This program is designed to prepare the graduate for a professional career in the polymer industries, of which plastics is the largest; the others include man made fibers, rubber, coating, and adhesives. The curriculum provides a sound basis in mathemetics, chemistry, and engineering, plus a full study of plastic materials, properties, process engineering, and product design, and includes sufficient flexibility for further specialization in areas of individual interest. Undergraduates also have the privilege of joining the first student chapter of the International Society of Plastics Engineers. (SPE)

Since the program started in 1954, more than 500 B.S. graduates have gone into polymer industries throughout the United States, Europe, and Asia. Major plastics producers and users recruit annually on campus. While most job openings are in product and process development and in technical service and marketing, some of the graduates also go into research, manufacturing, consulting, and teaching.

COURSES OF STUDY FOR PLASTICS ENGINEERING

Freshman Year

Fall Semester			Spring Semester		
84-121*	Chemistry	3	84-126*	Chemistry	3
84-123*	Chemistry Lab	1	84-124*	Chemistry Lab	1
42-101	College Writing	3	42-102	College Writing & Literature	3
92-131	Calculus B-I		92-132	Calculus B-II	
or			or		
92-133	Calculus A-I	4	92-134	Calculus A-II	4
95-141*	Introductory Physics	3	95-144*	Fundamentals of Physics I	3
96-141*	Fund of Exp. Physics I	1	96-144*	Fund. of Exp. Physics II	1
	Physical Education			Physical Education	
		15			15

*84-135 Honors Chemistry and, 84-137 Honors Chemistry Lab
95-147 Honors Physics and, 96-147 Fund. of Experimental Physics I may be substituted.

*84-136 Honors Chemistry and, 84-138 Honors Chemistry Lab.
95-148 Honors Physics and, 96-148 Fund. of Experimental Physics II may be substituted.

Sophomore Year

Fall Semester

84-223	Intro. Organic Chemistry I	3
84-225	Intro. Organic Chemistry Lab. I	1
92-231	Calculus B-III	4
or		
92-233	Calculus A-III	3
92-361	Digital Computer Programming	2
22-215	Analytic Mechanics I	3
26-201	Polymeric Meterials I	3
26-215	Plastics Processing Lab I	1
	Humanistic - Social Elective	3
		19 or 20

Spring Semester

84-224	Intro. Organic Chemistry II	3
84-226	Intro. Organic Chem. Lab II	1
22-216	Analytic Mechanics II	3
26-202	Polymeric Materials II	3
26-204	Process Control Systems	3
22-216	Plastics Processing Lab II	1
26-272	Intro. to Plastic Tooling Op.	1
	Humanistic Social Elective	3
		18

Junior Year

Fall Semester

22-347	Elements of Thermodynamics and Heat Transfer	3
22-395	Materials Science	3
64-201	Economics I	3
26-301	Polymeric Materials III	2
26-315	Plastice Processing Lab III	1
26-373	Plastics Mold Engineering I	3
	Humanistic - Social Elective	3
		18

Spring Semester

84-339	Physical Chem. Principles	3
84-341	Physical. Chem.Principles Lab	1
26-302	Polymeric Materials IV	2
26-316	Plastics Processing Lab IV	1
16-350	Intro. to Elec. Power/Mach.	3
26-314	Fluid Power Systems	3
	Humanistic - Social Elective	3
		16

Senior Year

Fall Semester

84-403	Intro. Physical Chemistry of Macromolecules	3
84-405	Polymer Laboratory I	1
26-401	Plastics Process Eng. I	3
26-403	Physical Properties of Polymers	3
26-415	Physical Properties Lab I	1
26-411	Plastics Seminar	1
	Undesignated Elective*	3
	Humanistic - Social Elective	3
		18

*ROTC Students may substitute 29-401

Spring Semester

84-404	Intro. Organic Chemistry of Macromolecules	3
84-406	Polymer Laboratory II	1
26-402	Plastics Process Eng. II	3
26-406	Polymer Structure	3
26-416	Physical Properties Lab. II	1
26-412	Plastics Seminar	1
	Humanistic - Social Elective	3
	Undesignated Elective*	3
		18

*ROTC Students may substitute 29-402

GENERAL COLLEGE REQUIREMENTS

Each candidate for an undergraduate degree must satisfy the general University requirements for graduation, complete all credits as specified in one of the department curricula, and meet the specific academic requirements of the College of Engineering as specified in this section. The number of credits required for graduation is established by the departments and ranges from 127 to 138.

With the exception of majors in industrial technology, all students in the College of Engineering take the same program in their freshman year. Candidates from the freshman year seeking admission to the sophomore program in civil engineering, chemical engineering, electrical engineering, mechanical engineering, nuclear engineering, and plastics engineering, automatically qualify for admission upon completing their common freshman year with a grade point average of 2.00 or better. Other freshman candidates will be admitted to the sophomore year of these programs only upon the recommendation of appropriate departmental committees and the concurrence of the Academic Standards Committee of the College of Engineering.

In addition to meeting the required minimum overall University grade-point average, students enrolled in programs offered by the College of Engineering must earn a 2.00 grade point average in major subjects specified by their department in order to graduate. In these subjects, each student must earn a minimum grade point average of 1.70 at the end of the sophomore year and 1.90 at the end of the junior year. Students who failed to achieve the specified grade point average in the sophomore and junior year for department listed subjects have not made satisfactory progress toward their degree, and unless the student petitions and receives approval of the department and the concurrence of the Academic Standards Committe of the College of Engineering, he or she will be dismissed from the College for inadequate scholarship.

Residency Requirement

In addition to the minimum University residency requirements, the College of Engineering requires students transferring to a degree program to earn at least thirty semester credits as specified by one of the established programs of the College.

Attendance Requirement

The College values regularity of attendance in classroom and laboratory sessions as a means of achieving collegiate success. Each instructor is required to state his or her attendance regulations in writing at the beginning of each course. Students who have exceeded the number of permitted absences may be failed by the instructor unless they have withdrawn from the course before the established University deadline.

Declaration of Major

Students enrolled in the College of Engineering of necessity are committed to pursue one of the established college programs and are encouraged to declare their choice of degree program upon enrollment. In any event, engineering students are required to declare a major area of study by the end of the freshman year or upon completion of the freshman core program and must file the appropriate form with the Office of the Registrar no later than the beginning of the sophomore year.

Change of Major

Students who wish to change their major and degree program within the College of Engineering must secure the approval of the chairperson of the appropriate department of the College. Students who wish to change their major and to elect a major offered by another college of the University should consult the policy concerning intercollegiate transfer with the University which appears in the publication concerning *Admission Regulations and General Academic Rules.* All such changes of program require notification of the Office of the Registrar through the filing of the form for Declaration of Major or Change of Major. Students who withdraw from the University must do so through the Office of the Registrar. Additional course work beyond the minimum degree requirements and extension of the normal four-year period of study may be expected for students who change their major options later than the first semester of their junior year or who change their degree programs later than the end of the freshmen year. Students may transfer into degree programs of the College of Engineering from other colleges of the University. However, students making such a transfer may expect to extend their period of study beyond the normal eight semesters, particularly if they transfer after the first semester of the sophomore year.

Transfer Policies

Course credits for transferred work are evaluated by the Office of Admissions at the time of student transfer and in accordance with general policies of the University. Since the nature of professional and specialized programs precludes the application of non-equivalent transfer courses to specific curriculum requirements, the records of transfer students are also evaluated by major departments at the time a student is accepted for matriculation by one of the colleges of the University. All transferred courses which have been accepted by the University are listed on the student's permanent record card, and those courses which are not applicable to specific curriculum requirements are credited, whenever possible, as "unrestricted elective courses."

Since some curricula do not provide for such "unrestricted elective courses," or the number of transferred courses may exceed the number of "unrestricted elective courses" which are permitted within the specifications for a minimum degree requirements, transferred courses which are not applicable to the specific requirements of a curriculum are not counted in the determination of the number of "course hours completed" until the semester of graduation. (Cf. "Academic Standing," *Admission Regulations and General Academic Rules,* for an explanation of "course hours completed.") This procedure prevents the early imposition of a grade point requirement for retention which is in excess of that specified for the number of credits completed and applicable to the student's particular curriculum. For instance, a student who transfers 60 credits is required to achieve a grade-point average of 1.80 for the first 15 credits attempted at the University. In the event that 30 of these credits are not applicable to his professional or academic curriculum, he will be charged with the completion of 30 course credits and will be required to achieve a grade-point average of 1.60 for the first 15 credits attempted at the University.

The applicability of grades received in transferred courses for the determination of the grade point average of the student's major at the University of Lowell is determined by policies of each of the colleges. The policy of the College of Engineering is to count such grades for the purpose of determining the student's major grade point average.

Repetition of Transfer Courses at the University

A student who has been granted transfer credit, and on this basis has been assigned to advanced courses for which the transferred course is a prerequisite, may be advised to repeat such transferred work at the University or to take a more elementary course than that which has been transferred when the competence of the student has been demonstrably inadequate. Permission to repeat a transferred course is granted by filing an academc petition form through the office of the College dean. Since credit may not be granted more than once for the completion of any course, a condition for filing such a petition is the simultaneous filing of a request to revoke recognition of the previously transferred course.

Intercollegiate Transfer within the University

Procedures for making an intercollegiate transfer within the University are described under the heading for "Change of Enrollment Status" in the publication concerning Admission Regulations and General Academic Rules. Students who have been approved for transfer to this College from other colleges of the University may apply for deletion of unrelated courses from their cumulative grade point average in accordance with established University policy. Such deleted courses are not removed from the permanent record card and may be recomputed in the cumulative grade point average in the event of a subsequent intercollegiate transfer.

Curriculum Requirements for the Graduating Classes of 1977 and 1978

Curriculum requirements of the College of Engineering which were in effect prior to June, 1975, continue to apply to students of the College who are members of the graduating classes of 1977 and 1978. These requirements include the specifications for majors and general degree requirements. Students who transfer to the College of Engineering from other institutions or from other colleges of the University and who are granted advanced standing in the classes of 1977 and 1978 are subject to all requirements in effect for these classes. For specific information concerning these requirements, students should consult the *Bulletin of the Lowell Technological Institute*, 1974-1975, or should confer with their faculty advisors and major department chairpersons.

COURSE DESCRIPTIONS

Each course offering is designated by a two-digit college prefix and a three-digit course number. The two-digit college prefix identifies a college department and/or special subject area. In some cases the prefix also identifies laboratory or lecture courses and courses which are primarily for majors and minors. The three-digit course number identifies the course level.

COURSE PREFIXES

The following numerical prefixes are assigned to the Department of Aerospace Studies and the seven colleges:

Aerospace Studies	29	Liberal Arts	40-59
Education	01-09	Management Science	60-69
Engineering	10-28	Music	70-79
Health Professions	30-39	Pure & Applied Sciences	80-99

Courses prefixes assigned by the College of Engineering are as follows:

Chemical Engineering	10	Industrial Technology	20
Civil Engineering	14	Mechanical Engineering	22
Electrical Engineering	16	Nuclear Engineering	24
		Plastics Engineering	26

COURSE NUMBERS

Courses numbered 001-049 are prefreshman and special undergraduate courses and do not carry baccalaureate degree credit. Those numbered 100-299 are lower-division undergraduate courses and those numbered 300-499 are upper-division undergraduate courses. The 400 level courses are generally limited to juniors and seniors majoring in a field but are open, with permission, to other advanced undergraduates and to graduate students. Directed studies courses and practicum experience courses are generally limited by departmental policy to students majoring in the area in which such courses are offered. Courses numbered 500-599 are graduate courses which are open to upper-division undergraduates with the consent of instructors and chairpersons. Courses numbered 600-699 are graduate courses which are open only to graduate students. Courses numbered 700-799 designate graduate research projects and graduate theses.

SEMESTER, CLASS, AND CREDIT DESIGNATIONS

Courses which are offered during the fall semester are designated by the Roman Numeral I; spring semester courses are designated by the Roman Numeral II, and courses which are offered during both fall and spring semesters are designated by the Roman numerals I and II. Courses which are not prescheduled for specific semesters carry no Roman numerical designation. In the event that a course is given during the first half of a semester, the Roman number is followed by the letter A. A course which is given during the second half of a semester is followed by the letter B.

Arabic numbers enclosed in parentheses indicate the number of hours of lecture/recitation and of laboratory/applied activity. The Arabic number following the numbers in parentheses is a designation of course credit. For example, the designation IB (6,0) 3 means that a course is offered during the second half of the fall semester, requires 6 hours of lecture/recitation per week, and carries 3 semester credits. Similarly, the designation II (2,6) 4 means that a course is offered during the spring semester, requires 2 hours of lecture/recitation per week and 6 hours of laboratory/applied activity per week, and carries four semester credits.

COURSE RESTRICTIONS

Special course prerequisites, corequisites, and enrollment restrictions are indicated at the end of the course description. A course which is listed as a prerequisite must have been completed and passed prior to taking the course for which the prerequisite is specified. An exception to this limitation may be granted by the designated instructor only. A course which is listed as a corequisite must be taken during the same semester as the course for which the corequisite is specified. Courses which carry such notations as "open for majors only" and "sophomore status required" are restricted to the specified students. Courses which carry the notation "permission of instructor" require instructor approval prior to filing enrollment cards with the Office of Registrar. Courses at the 100-300 levels which do not carry prerequisite, corequisite and enrollment restrictions are open for election by all students unless general restrictions have been listed under the department or course area heading.

INSTRUCTOR DESIGNATION

The instructor who is designated to teach a course for the current academic year may be listed at the end of the course description. Courses which carry no instructor designation are taught by members of the department or by unassigned faculty members.

DEPARTMENT OF CHEMICAL ENGINEERING (COURSE PREFIX 10)

10-203 INTRODUCTION TO CHEMICAL ENGINEERING CALCULATIONS I (3,0) 3

Introduction to the field of chemical engineering and the solution of problems involving units and dimensions, mass balances, flow sheets and ideal gas relationships.
Prerequisites: 84-126 or 84-128.

10-204 CHEMICAL ENGINEERING CALCULATIONS II (3,0) 3

Continuation of Introduction to Chemical Engineering Calculations including real gas relationships, humidity, energy balances, and the combined mass-energy balance systems. Prerequisite: 10-203.

10-206 FLUID MECHANICS II (2,0) 2

Introduction to fluid statics and application of fluid mechanics principles to the analysis and design of fluid systems. Design of fluid meters and conduits. Friction factor, pressure drops in laminar and turbulent flow and the introduction to boundary layer theory. Prerequisite: 10-203.

10-207 COMPUTER PROGRAMMING FOR CHEMICAL ENGINEERS I (1,2) 1

Introduction to FORTRAN IV programming, statements, control, Do loop and subscripted variables, functions and subroutines, input and output. Emphasis is placed on FORTRAN application to chemical engineering problems, selected numerical methods. Six to eight problems will be individually handled by each student on the University computer facilities.

10-208 CHEMICAL ENGINEERING LABORATORY I II (0,3) 1

The laboratory work involves the study of various fluid flow systems under laminar and turbulent status of flow; also included are various aspects of technical report writing. Corequisite: 10-206.

10-305 HEAT TRANSFER I (3,0) 3

Fundamental principles of heat transmission by conduction, convection, radiation and evaporation. Applications of these principles to the solution of industrial heat transfer problems and to the preliminary design of heat exchange equipment including evaporators. Prerequisites: 10-204, 10-206, 92-232 or 92-234.

10-306 TRANSPORT PHENOMENA II (3,0) 3

Introduction to the theory of momentum, energy and mass transfer. Integral and differential approaches. Macroscopic and microscopic balances. Application of macroscopic balances to the solution of practical problems in chemical industry. Prerequisites: 10-206, 10-305, 92-302.

10-308 ENGINEERING MATERIALS II (3,0) 3

Study of materials for engineering construction and chemical purposes from standpoint of physical and chemical properties, corrosion and introductory electrochemistry. Structures of metals, non-metals and polymeric materials. Structure of materials related to ultimate performance. Prerequisites: 84-126, 84-224.

10-310 SEPARATION PROCESSES II (3,0) 3

Introduction to each of the separation processes, distillation, absorption, extraction, and humidification. Material balances and energy balances, mass transfer relations, equilibrium relations. Graphical and numerical methods for solving problems, iterative methods for use with a digital computer. Prerequisites: 10-204, 92-234.

10-311 CHEMICAL ENGINEERING THERMODYNAMICS I (3,0) 3

Development of the First and Second Laws of Thermodynamics, P-V-T relations, mathematics of property changes, generalized correlations of thermodynamic properties, application of thermodynamics to problems of phase and chemical equilibria. Prerequisite: 10-204.

10-315 CHEMICAL ENGINEERING LABORATORY II I (0,3) 1

Experimental projects designed around various unit operations problems involving both steady and non-steady state heat transfer. Reports required. Prerequisite: 10-206; Corequisite: 10-305.

10-316 CHEMICAL ENGINEERING LABORATORY III II (0,3) 1

Experimental projects designed around unit operations equipment that includes the combined effects of fluid flow, heat transfer, and mass separation processes. Reports required. Prerequisite: 10-315; Corequisite: 10-310.

10-401 PAPER INDUSTRY PROCESS ANALYSIS I (3,0) 3

Lectures dealing with processes of fiber separation from raw materials, fiber purification, mechanical processing of fiber and sheet formation. Chemical Engineering theory is applied to the analysis of these operations. Prerequisite: 10-204.

10-402 ENGINEERING ANALYSIS OF COATING AND CONVERTING SYSTEMS II (2,3) 3

Lectures and problems concerned with the engineering design, technology and economics of paper and paperboard processes. Rheology and engineering properties of coating materials. Mechanical processes, coating, impregnating, laminating and printing processes discussed in detail. Prerequisite: 10-401.

10-403 KINETICS AND REACTOR DESIGN I (3,0) 3

Review of principles underlying rates of transformation of matter and energy; effect of temperature and catalysis on chemical reactions; application to design of chemical reactors; use of digital computers in solution of problems. May be taken for graduate credit. Prerequisites: 10-305, 10-306, 10-310, 92-302.

10-404 PROCESS CALCULATIONS OF PULP AND PAPER PROCESSES II (3,0) 3

Mathematical analysis of various processes using energy and material balances. Application of theory to the design of paper of various structure and properties. Prerequisite: 10-204.

10-405 DESIGN OF PAPERS I (3,3) 4

Fundamentals of the mechanical and optical testing of paper and allied products. Discussion of engineering mechanics involved in various testing procedures. Statistical analysis of test data. Structure of materials revealed by physical tests. Laboratory projects designed to illustrate problems in design of pulps and paper.

10-409 ECONOMICS AND PROCESS ANALYSIS I (3,0) 3

This course brings together all of the Chemical Engineering disciplines into the development of a preliminary plant design. A term paper as a series of group efforts is required together with an oral presentation of the term paper. The term paper presents a preliminary evaluation of the economics, marketing and the preliminary evaluation of a particular product. Lectures emphasize the basic economics and the time value of money as well as the methods of depreciation. Capital costs and Operating costs are emphasized. Term Paper on design required. Prerequisites: 10-306, 10-310 or permission of instructor.

10-410 CHEMICAL PLANT DESIGN II (3,0) 3

Applications of transport phenomena and separation processes, economics and process analysis in the design of complete chemical plants; optimization of plant equipment. Flow sheets, specifications for equipment and a term paper on an economic estimate of the total plant cost is required for the course. Prerequisites: 10-306, 10-310, 10-403, 10-409.

10-413 PROCESS DYNAMICS AND CONTROL I (3,0) 3

An introduction to chemical process control, description of processes and equipment by differential equation and the LaPlace Transform. Development of block diagram. System Stability is studies by both Root Locus and Frequence Responses methods. Prerequisites: 92-302, 10-305, 10-306, 10-310.

10-416 PROCESS CONTROL LABORATORY II (1,3) 2

Application of theory from 10-413, with laboratory experience in process simulation, analog and digital computer applications. Advanced topics in control are covered. Prerequisite: 10-413.

10-419 SPECIAL SENIOR PROJECTS CREDITS ARRANGED

Original research projects primarily in the Chemical Engineering field and supervised by a staff member of the Department. Reports required on work done. Prerequisite: permission of instructor.

10-420 SPECIAL SENIOR PROJECTS CREDITS ARRANGED

Continuation of 10-419.

10-422 CASE STUDIES IN CHEMICAL ENGINEERING II (3,0) 3

Discussion of a number of chemical engineering processes from the standpoint of engineering theory and reduction to practice. Plant visits will be used to illustrate real-life engineering solutions. Oral and written reports required. Prerequisites: 10-203, 10-315.

10-424 ANALYSIS OF CHEMICAL PROCESS INDUSTRIES II (3,0) 3

An examination of the chemical process industries showing their interrelationships and interaction with other industries. Process analysis and economics are stressed. Selected processes are studies in detail to illustrate processing problems, alternative raw materials, environmental and marketing problems. A term paper is required. Prerequisite: permission of instructor.

10-430 THE ENGINEER AS AN ENTREPRENEUR II (3,0) 3

This course introduces the problems of becoming an entrepreneur. Steps to be followed in setting up one's own business are outlined in detail, with stress on the hazards and solutions to entrepreneurship. Real case studies are used to illustrate the points. A term paper is required by groups of students in the establishment of their own business. Outside speakers emphasize various aspects of entrepreneurial problems. Prerequisite: permission of instructor.

10-431 COAL TECHNOLOGY I (3,0) 3

The formation, distribution, types and chemistry of coal are studied. Uses of coal both for energy and as a chemical raw material are developed. Gasification of coals, development of products and processes from coal and its byproducts are studied from the standpoint of overall technology, economics and relationship to other sources of chemical raw materials. Prerequisite: permission of instructor.

10-434 PETROCHEMICALS II (3,0) 3

A review of the petroleum industry is made from the standpoint of its technology, markets, and influence on the petrochemical industries. Study of the technical methods of manufacture of various chemical raw materials are made with appropriate attention being paid to economics, marketing, alternate sources of materials and processes, and chemical engineering aspects of various processes involved. Particular attention is paid to catalysis, equilibrium reactions and kinetics. A term paper is required. Prerequisite: permission of instructor.

10-435 POLYMERIZATION PROCESSES - A CHEMICAL ENGINEERING VIEW I (3,0) 3

A review is made of the various types of polymeric materials and the monomers from which they are made. Detailed studies are made of addition and condensation polymerization processed. Emphasis is placed on the current technology of high pressure and low pressure processes with specific attention being given to the polyolefins, polystyrenes, polyvinyl chlorides and polyamids. Economic evaluations of these processes and their relationship to the plastics and other industries will be detailed. Prerequisite: permission of instructor.

10-436 ENERGY UTILIZATION II (3,0) 3

Declining resources and the energy crisis have made an intensive review of the utilization of various and actual forms of energy mandatory. This course covers the various forms of energy, a detailed review of the technology of these energy sources and the inter-relationships of these energy forms. Economic evaluations are made of the various levels at which the components of the energy field may compete. Economic utilization of various natural resources both as a source of energy and as a source of chemical raw materials will be evaluated. Reports and term projects will be required. Prerequisite: permisssion of instructor.

10-440 ESTIMATION OF ENGINEERING PROPERTIES II (3,0) 3

Discussion of currently available methods of estimation of physicochemical properties, analysis of published experimental data, curve fitting and nomography, interpolation and extrapolation of data, statistical and numerical methods, dimensional analysis. Prerequisite: permission of instructor.

10-503 MASS TRANSFER OPERATIONS I I (3,0) 3

Detailed coverage of the fundamentals of separation processes of absorption and extraction. Degrees of freedom, phase equilibrium diagrams, graphical techniques. Molecular diffusion, interphase mass transfer, mass transfer and simultaneous chemical reaction. Design principles for multistage countercurrent contactors and continous differential-contact columns. Prerequisite: permission of instructor.

10-506 COLLOID CHEMISTRY FOR CHEMICAL ENGINEERS II (3,0) 3

Colloid chemistry principles applied to chemical engineering process problems; zeta potential and its applications; specific problems involving surface chemistry and physics. Prerequisite: permission of instructor.

10-509 CHEMICAL ENGINEERING ANALYSIS I (3,0) 3

Applications of mathematics to chemical engineering problems; unsteady state equations and problems; special graphical solutions; use of computer for solution of complicated problems; specific real engineering problems. Prerequisite: permission of instructor.

10-511 STRUCTURE AND PROPERTIES OF MATTER I (3,0) 3

Fundamental properties of matter as they relate to chemical engineering problems. Materials of construction. Rheological properties of polymeric materials and their application to chemical engineering. Prerequisite: permission of instructor.

10-517 MASS TRANSFER OPERATIONS II I (3,0) 3

Fundamentals and modeling techniques for the separation process of distillation. Flash distillation, batch distillation, multicomponent distillation. Shortcut design method, Lewis-Matheson method, Thiele-Gedds method, Wang-Henke method, other methods. Optimization. Prerequisite: permission of instructor.

10-520 ADVANCED THERMODYNAMICS I (3,0) 3

A critical examination of classical thermodynamics from a chemical engineering viewpoint emphasizing the fundamental laws. General thermodynamic relations are used to develop equations for pure, ideal gases and real substances. Selected topics in applications of thermodynamics to equilibrium systems, refrigeration and other equipment. Prerequisite: permission of instructor.

10-521 INTRODUCTION TO ENVIRONMENTAL ENGINEERING I (3,0) 3

This is an introductory course to the problems of environmental pollution in all its aspects. Air and water pollution are given particular emphasis and special projects are assigned for student investigation. The course is concerned with the assesssment and evaluation of the magnitude of the problem, but does not consider in depth the known or possible solutions to environmental pollution problems. Prerequisite: permission of instructor.

10-524 ADVANCED CHEMICAL PROCESS I (3,0) 3

Detailed study of several commercial processes from the standpoint of engineering principles and economics. Economics and interrelationships of the chemical industry. Analysis of specific real problems. Factors involved in determination of best design from several alternatives. Term paper required. Prerequisite: permission of instructor.

10-526 ADVANCED HEAT TRANSFER II (3,0) 3

Review of principles of energy transport. Specific problems in convection and ratiant heat transfer. Mathematical treatment of unsteady-state heat transfer. Prerequisite: permission of instructor.

10-528 INTERMEDIATE TRANSPORT PHENOMENA II (3,0) 3

A systematic, fundamental approach to momentum, heat and mass transfer. Transport equations are developed both on the microscopic and macroscopic viewpoint. Analogies and similiarities between the transfer processes are discussed. Considerable emphasis is placed upon solutions to problems. Prerequisite: permission of instructor.

DEPARTMENT OF CIVIL ENGINEERING (COURSE PREFIX 14)

14-203 STATICS I (3,0) 3

Vector concepts of forces and moments of forces. Equilibrium of rigid bodies and simple structures at rest. Static friction. Geometric properties of sections. Prerequisites: 92-132 or 92-134, 95-144, 96-144.

14-204 STRENGTH OF MATERIALS II (3,0) 3

The concept of stress and strain at a point. Stress temperature relationships. Force and deformation analyses of bodies under axial, shearing, flexural torsional and combined loadings. Column buckling. Shear and bending moment diagrams. Prerequisites: 92-231 or 92-233, 14-203.

14-220 SURVEYING I I (3,4) 4

Principles of data gathering by surveying processes for the measurement and determination of lengths, directions, coordinates, areas, volumes and topographic information. Illustrative fieldwork to give facility in basic surveying techniques; problems are used to demonstrate processing of field data. Prerequisites: 92-131 or 92-133; Corequisite: 14-223.

14-221 SURVEYING II II (3,4) 3

Application of basic surveying techniques to the solution of engineering problems implicit in such Civil Engineering areas as transportation, industrial and domestic structures, utilities for the safety and convenience of humans, and water supply and control. Fieldwork projects typical of application of surveying to Civil Engineering. Prerequisite: 14-220.

14-223 GRAPHICS I (0,3) 1

An introduction to the basic principles of engineering drafting including such topics as engineering lettering, orthographic projections and pictorial representation of solids. Includes the application of graphical methods to typical Civil Engineering projects.

14-301 FLUID MECHANICS II (3,0) 3

Fluid properties, fluid statics, fluid dynamics including continuity, impulse-momentum and energy equations. Pipe flow, turbomachinery, similitude and modeling. Emphasis will be on incompressible fluids. Prerequisite: junior status.

14-310 ENGINEERING MATERIALS I (2,3) 3

A treatment of the properties of engineering materials as such influence the design, construction and maintenance of Civil Engineering works. Included are such materials as ferrous and non-ferrous metals, timber, plastics, and cementitious materials. Also includes the description and identification of soils. Supplemented by laboratory testing of various engineering materials. Prerequisites: 84-126 or 84-128, 14-204.

14-340 TRANSPORTATION ENGINEERING II (3,3) 4

Development of the basic principles pertaining to the movement of people and goods by modern transportation systems. Aspects of planning and design of land, air and water transportation facilities. Analysis of the operating characteristics and of the economics of the various transportation modes. Prerequisites: 14-221, 14-310.

14-350 STRUCTURAL ANALYSIS I (3,3) 4

Principles of structural analysis applied to typical civil engineering structures as the initial step in the total design concept. Basic emphasis on the analysis of statistically determinate structures with elements of modern methods of analysis of indeterminate structures. The digital computer as an analytical tool. Prerequisite: 14-204.

14-351 STRUCTURAL DESIGN II (3,3) 4

An introduction to the fundamentals of the design of reinforced concrete, metal and timber structures. Both elastic and inelastic methods are used to design structural elements. Included are tension members, compression members, structural joints, floor systems, and footings. Prerequisites: 14-310, 14-350.

14-430 SOIL MECHANICS I (3,0) 3

Development of the fudamental principles of the science of soil mechanics as utilized in soil and foundation engineering. Includes index properties, classification, strength and deformation properties, and hydraulic properties which are required for foundation and soil engineering design. Prerequisites: 14-204, 14-310.

14-431 FOUNDATION & SOIL ENGINEERING II (3,0) 3

The application of soil mechanics to the design and analysis of foundations and soil structures. Includes slope stability analysis and the design of retaining structures, deep and shallow foundations, and the bracing of excavations. Introduction to soil mechanics laboratory practice covering determination of fundamental soil properties. Prerequisite: 14-430.

14-433 EXPERIMENTAL SOIL MECHANICS (0,3) 1

Introduction to Soil Mechanics Laboratory practice using standard tests for the determination of strength and compressibility characteristics of soil. Also includes the experimental determination, through the medium of term projects, of engineering properties of soil.

14-440 TRANSPORTATION PLANNING I (3,0) 3

Principles of transportation system analysis. Demand, supply and equilibrium flows in multimodel transportation networks. The urban transportation planning process. Collection of basic data, analysis and model building. Prediction of the future use of tranportation systems. Evaluation of alternative proposals. Prerequisite: 14-340. Gartner.

14-441 TRAFFIC ENGINEERING II (2,3) 3

Elements of traffic engineering: the road user, the vehicle, the roadway and geometric design. Traffic characteristics, volume studies, travel time and delay studies. Capacity and level of service. Planning for pedestrians. Parking studies analysis of accidents. Application of control measures. Prerequisite: 14-340. Gartner.

14-450 ADVANCED STRUCTURAL ANALYSIS II (3,0) 3

Classical and matrix methods of structural analysis applied to complex plane trusses. Elementary space truss analysis. Elementary model analysis through the use of influence lines for indeterminate structures. The digital computer and problem oriented languages as analytical tools. Prerequisite: 14-350.

14-451 ADVANCED STRUCTURAL DESIGN I (2,3) 3

A study of the design and construction of modern structures for students majoring in structural engineering. Emphasis is placed on special projects, case studies, and the use of the digital computer. Special topics included are torsion of non-circular members, prestressed concrete, beam-columns, design of flat slabs, and elementary earthquake design. Prerequisite: 14-351. Tartaglione.

14-460 WATER RESOURCES ENGINEERING I (3,0) 3

Elements of classical hydrology including groundwater, hydrographs, and statistical analyses of data. Open channel flow and water law. Prerequisite: 14-301.

14-461 WATER RESOURCES DESIGNS II (1,3) 2

Water distribution networks, sewers, culverts, and drainage systems. Flow prediction and hydrograph generation. Waterhammer and surge; and gradually varied flow. Prerequisite: 14-460.

14-462 SANITARY ENGINEERING I I (3,1) 3

Physical, chemical and biological principles of the treatment of water and sewage are considered along with their application to treatment systems. The several system components of water and sewage treatment plants are studied to provide a basis for design capability. Prerequisite: 14-301. Ott.

14-463 SANITARY ENGINEERING II II (3,1) 3

A study of the effects of waste discharges on the aquatic environment. Streams, lakes and marine systems are considered. Modeling of effects are explored through use of the Streeter-Phelps equation and various modifications. Stream sampling techniques, data collection and analysis are stressed. Ott.

14-480 SPECIAL TOPICS IN CIVIL ENGINEERING (2,3) 3

Relevant civil engineering projects selected to synthesize the planning, analysis and design aspects of engineering problems. Results presented as technical reports. Prerequisite: Senior status.

14-481 ENGINEERING SYSTEMS ANALYSIS (3,0) 3

Introduction to methods of operations research, management science and economic analysis used in the design, planning and managing of engineering systems. Main topics covered: modeling of engineering systems, application of optimization methods, organizational networks, decision analysis, economic considerations in systems planning. Prerequisite: permission of instructor. Gartner.

14-504 ADVANCED STRENGTH OF MATERIALS I or II (3,0) 3

Stress and strain at a point; curved beam theory, unsymmetrical bending, shear center, torsion of non-circular sections; theories of failure; introduction to the theory of elasticity, elastic foundations. Prerequisite: permission of instructor. Leitch.

14-521 REMOTE SENSING I or II (3,0) 3

Electromagnetic energies reflected or emitted by the natural and cultural environment; current remote sensing systems; Imagery interpretation; Automatic image processing; Applications to land-use planning. Prerequisite: permission of instructor.

14-532 ADVANCED SOIL MECHANICS I or II (3,0) 3

Basic theories of soil mechanics and their application under practical conditions. It will deal with basic strength principles and stress-strain behavior of clay and cohesionless soil. Physical properties of soils will be determined in a laboratory portion of the course. Prerequisite: permission of instructor. Sewell.

14-535 ENGINEERING GEOLOGY I or II (3,0) 3

An introduction to the concepts and techniques of engineering geology. Topics will include the geology and morphology of glacial deposits; geological features and their engineering significance; use of borings and geophysical exploration techniques; geologic construction materials; groundwater, water supply, solid and liquid waste disposal; erosion and sedimentation associated with construction activities, reservoir silting and shoreline processes; and the geologic factors considered in earthquake engineering. Case studies and term projects dealing with such activities as land-use planning, reservoir silting, water supply, and dam construction will be included. Certain geologic features and construction projects of New England will be visited during the semester. Prerequisite: permission of instructor. Sewell.

14-551 DESIGN OF STEEL STRUCTURES I or II (3,0) 3

Elastic and plastic design of structural steel systems, residual stresses; beam-columns; torsion; composite steel-concrete members. Prerequisite: permission of instructor. Leitch.

14-553 TIMBER STRUCTURES I or II (3,0) 3

Design of timber members in tension, compression and bending; design of connections, laminated wood trusses and frames. Prerequisite: permission of instructor. Leitch.

14-455 STRUCTURAL ANALYSIS BY MATRIX AND NUMERICAL METHODS I or II (3,0) 3

Basic structural analyses theories using Energy and Equilibrium techniques. Introductory studies of structures by use of finite differences, finite elements and other iterative methods. Applications to truss, beam, and plate elements using computers. Special studies in elastic stability. Prerequisite: permission of instructor. Haskell.

14-562 GROUNDWATER HYDROLOGY I or II (3,0) 3

Descriptive and analytic treatment of the occurence, movement and fluctuation of groundwaters will be given. The response of groundwater to wells and the methods of obtaining solutions to well pumping problems will be included. Also to be investigated will be aquifer development and the problem of groundwater and aquifer pollution. The hydrology of landfill leachate will be presented. Prerequisite: permission of instructor. Moeller.

14-563 HYDRAULICS OF OPEN CHANNELS I or II (3,0) 3

Problems of varied or non-uniform flow in open channels will be investigated including methods for making surface and back-water profile determinations. Applications and typical cases will be of primary interest. Design capability should be enchanced for channel, canal, ditch, storm and sanitary sewer flow problems, and for hydraulics of reservoirs and treatment works under unsteady flow conditions. Prerequisite: permission of instructor. Moeller.

14-564 HYDROLOGY I or II (3,0) 3

Basic hydrologic concepts; generation of input for design by processing of time series, correlations and frequency distribution. Prerequisite: permission of instructor. Moeller.

14-565 INDUSTRIAL WASTE TREATMENT PROCESSES I or II (3,0) 3

An introduction to the unit operations most commonly encountered in industrial waste treatment. Specific industrial applications will be stressed after an understanding of each unit operations has been developed. Prerequisite: permisssion of instructor. Ott.

DEPARTMENT OF ELECTRICAL ENGINEERING (COURSE PREFIX 16)

16-201 INTRODUCTORY CIRCUIT THEORY I I (4,0) 4

Terminal characteristics of ideal elements, active and passive. Ohm's Law and Kirchhoff's Laws. Introduction to network topology, independent variables, loop and nodal analysis. Definition and consequences of linearity, superposition theorem. Concept of excitation and response. Passive equivalent circuits; active equivalent circuits, Thevenin's and Norton's theorems. Ideal inductance and capacitance, volt-ampere characteristics, energy relations, graphical differentiation and integration. First-order transients: initial conditions, natural response and natural frequencies. Network response to unit step function and unit impulse. Second-order transients: RLC circuits, natural frequencies and the complex-frequency s-plane. Prerequisite: 92-132 or 92-134, Corequisite; 95-245.

16-202 INTRODUCTORY CIRCUIT THEORY II II (4,0) 4

Sinusoidal forcing function, complex numbers, phasors, sinusoidal steady-state. Average real power, reactive power and rms values. Exponential forcing function, poles and zeros in the s-plane, concept of the system function and its use in determining the forced response and natural behavior of circuits. Frequency response and resonance, reactance cancellation and concept of s-plane vectors. Thevenin's and Norton;s theorems, superposition, reciprocity, and maximum power in the frequency domain. Magnetic coupling, mutual inductance, ideal transformer. Impedance and admittance and hybrid parameters for a two-port network. Introduction to matrices and their use in circuit analysis. General responses by pre-box techniques. Prerequisite: 16-201 - Introductory Circuit Theory I.

16-207 BASIC ELECTRICAL ENGINEERING LABORATORY I I (1,3) 2

Experimental work designed to verify theory and to acquaint students with electrical measurement techniques: experiments on dc meters, bridges, and oscilloscopes. Remainder of experiments are correlated with course 16-201 and concern: resistive measurements, Kirchhoff's Laws, network theorems, conservation of power and maximum power transfer, inductance and capacitance, and first and second-order transients. Corequisite: 16-201.

16-208 BASIC ELECTRICAL ENGINEERING LABORATORY II II (1,3) 2

Experimental work, desiged to emphasize electrical measurement techniques of linear systems with time-varing signals. Waveform measurements with dc ac meters as well as advanced use of the oscilloscope with experiments integrated with course 16-202. Experiments concern: Kirchhoff's Laws for phasors, magnitude and phase measurements of impedance, network theorems, frequency response, resonance, inductance and transformers, and maximum power transfer. Prerequisite: 16-207 and Corequisite 16-202.

16-211 FUNDAMENTALS OF ELECTRICITY I (3,0) 3

An introduction to the basic principles of electricity, including the concepts of voltage, current resistance, inductance, capacitance, energy, and power; Ohm's and Kirchhoff's Laws; Thevenin's and Norton's Theorems; RC and RL transient analysis; the concepts of average and root mean square values; and the analysis of steady state alternating current circuits including complex impedance and phasor notation. Prerequisite: 92-132 or 92-134; Corequisite: 95-245. Not open to students majoring in Electrical Engineering.

16-212 INTRODUCTORY ELECTRONICS II (3,0) 3

The characteristics of two and three terminal devices such as the diode, transistor, programmable unijunction transistor, silicon controlled rectifier, triac, and field effect transistor; Graphical analysis including both alternating current and direct current load lines; transistor amplifier circuits; rectifier and silicon controlled rectifier circuits; and introduction to digital logic and devices; analog computing elements; rotating machines including shunt, series and three phases induction motors. Prerequisite: 16-211. Not open to students majoring in Electrical Engineering.

16-214 ELECTRICAL MACHINERY LABORATORY II (0,3) 1

A laboratory course devoted to basic measurement techniques of power consuming and generating equipment. The terminal characteristics of alternating and direct current rotating machines are studied. Transformers and solid-state power control circuitry are investigated. Corequisite: 16-211 or 16-348.

16-311 ELECTRONICS LABORATORY I I (1,3) 2

A laboratory course with experiments coordinated with the subject matter of 16.365. Characteristics and use of dual-trace oscilloscopes employing a variety of plug-in amplifiers, and other related electronic equipment. Methods of characterizing diodes and transistors. Analysis of performance characteristics of digital and linear semi-conductor circuits, including logic elements and amplifers at low frequencies. Corequisite: 16.365.

16-312 ELECTRONICS LABORATORY II II (1,3) 2

A laboratory course with experiments coordinated with the subject matter of 16.366. High-frequency characteristics of transistors and transistor amplifiers. Feedback in electronic circuits. Electronic oscillators. Differential amplifiers. Properties of linear IC operational amplifiers, and their application in amplifier circuits and waveform generation circuits. Digital and linear circuit design and analysis. Prerequisite: 16.311; Corequisite: 16.366.

16-327 PROGRAMMING AND APPLICATION OF DIGITAL COMPUTERS I I (2,0) 2

Elementary computer organization and information flow concepts are developed. The theme of problem interpretation and analysis is stressed through program flow charting, coding, and documentation. The FORTRAN IV programming language is used to solve problems involving numerical integration, series solutions, list sorting, array manipulation and elementary matrix operations. The interpretation of computer results and verification of program correctness are emphasized. Corequisite: 16-202 or 16-361.

16-328 PROGRAMMMING AND APPLICATION OF DIGITAL COMPUTERS II II (2,0) 2

An introduction to programming techniques required in the development of large programs with emphasis on user-developed main programs that link disk-stored subprograms. Topics include definite and indefinite numerical integration, piecewise-linear function generation, first order linear and nonlinear differential equations, simultaneous equations with real variables, determination of the magnitude and phase of rational functions, time domain and frequency domain plots. Prerequisite: 16-327.

16-348 BASIC ELECTRICAL ENGINEERING CONCEPTS II (3,0) 3

An introduction to the basic principles of electricity, including the concept of voltage, current, resistance, inductance, and capacitance; Ohm's and Kirchhoff's Laws; Thevenin's and Norton's Theorems. Other areas of coverages will include sinusoidal steady state analysis of RLC circuits, motor and generator concepts and an introduction to solid state devices including the seminconductor diode and transistor. Prerequisite: 92-132 or 92-134.

16-350 INDUSTRIAL ELECTRICAL POWER II (3,0) 3

An introduction to direct current and alternating current analysis of circuits. Energy and power. Electromagnetism, transformers, rotating machines, and industrial measuring instruments. Single phase and polyphase systems as used in industrial plants. Efficiency and economic usage are emphasized. Electronic instrumentation as used in measurements and control. Prerequisite: 92-231 or 233.

16-351 INDUSTRIAL ELECTRONICS I (3,0) 3

The principles of alternating currents and direct current as a background for the understanding of electronic circuits. The elements of logic circuits, amplifiers, and power supplies. Transformers and rotating machinery; protective devices and industrial control circuits. Not open to students majoring in Electrical Engineering. Prerequisite: 92-132 or 92-134.

16-355 INTRODUCTORY ELECTROMECHANICS I (3,0) 3

Introduction to magnetic circuits, dc motors and generators, singly and multiply excited systems. Three phase circuits, three phase synchronous generators and motors. Transformer equivalent circuit, the autotransformer, three phase connections. Three phase induction motor, single phase motors. Corequisite: 16-202 or 16-361.

16-360 ELECTROMAGNETIC THEORY I II (3,0) 3

An intermediate course in electrostatics and magnetostatics using vector calculus. Topics include: the electric field, line and surface integrals, potential, the divergence theorem, Gauss law, capacitance, conductors, dielectrics, Poisson's and Laplace's equations, the Biot-Savart law, Stokes' theorem, scalar and vector magnetic potentials, force and torque on conductors, magnetic circuits and inductance. Prerequisite: 92-232 or 92-234.

16-362 SIGNAL AND SYSTEM ANALYSIS I, II (3,0) 3

Natural and forced response of linear systems; exponential excitation, system function and impulse response using sigularity balancing. Time-domain analysis of systems; orthogonal signals, Fourier series representation, convolution in the time domain. Frequency-domain analysis of systems; properties of Fourier and Laplace transforms and their application to the analysis of filters and electric circuits. Prerequisites: 16-202 or 16-361 and 92-232 or 92-234.

16-365 ELECTRONICS I I (3,0) 3

A brief introduction to solid-state physics, leading to discussion of physical characteristics of pn junction diodes and transistors. Circuit models for diodes, and diode applications. Circuit models for transistors, and transistor applications in digital circuits and low-frequency amplifier circuits. Analysis of digital circuits and linear circuits based on application of circuit models of devices and circuit theory. Prerequisites: 95-245, 16-202.

16-366 ELECTRONICS II II (3,0) 3

A continuation of 16.365 with discussion of multi-transistor circuits at high frequencies. Feedback amplifiers and oscillators. Differential amplifiers and operational amplifiers. Circuit design employing linear IC operational amplifiers. Examples of electronics applications in the areas of high-frequency circuits, power amplifiers, and hybrid analog/digital systems. Prerequisite: 16-365.

16-403 MICROWAVE DESIGN THEORY I (3,0) 3

An introductory course in the analysis and design of passive microwave devices beginning with a review of time-varing electromagnetic field concepts and transmission lines. Impedance mathing techniques, terminations, attenuators, phase changers, directional couplers, hybrids. Microwave devices employing Faraday rotation, electro-magnetic resonators. Survey of semiconductor devices suitable for microwave frequencies. Prerequisite: 16-461.

16-408 through 16-410 PROJECT LABORATORY I (0,4) 2

The purpose of this course is to provide an opportunity for qualified electrical engineering students to investigate specific areas of interest. The actual project undertaken may be software or hardware oriented or be a library research or some combination. The most important characteristics of the projects are that the end results represent an effort in independent study, that they are research and development oriented, and that they are accomplished with a practical attitude in an engineering environment. Design reviews, progress reports, and a final formal report is expected for each project. Prerequisite: permission of instructor.

16-411 LOGIC DESIGN OF DIGITAL SYSTEMS I I (3,0) 3

A review of number systems and base conversion. An introduction to Boolean algebraic and combinatorial logic concepts. Minimization techniques including Boolean algebraic manipulation, the Karnaugh map method, and the Quine-McCluskey tabular method. Simplification techniques are also applied to multiple output networks and incompletely specified functions. Error detection and correction codes. An introduction to sequential machines including state table, state diagram, and minimization concepts. Prerequisite: 16-328.

16-412 LOGIC DESIGN OF DIGITAL SYSTEMS II II (3,0) 3

The general characteristics of finite synchronous and asynchronous sequential machines. State diagrams, state tables, implication tables and graphs are used to determine equivalent states and therefore equivalent minimal sequential machines. State assignment and complete machine logic design. Hazards in combinational and sequential networks. Introduction to neural networks, Turing machines, and automata. Prerequisite: 16-411.

16-413 LINEAR FEEDBACK SYSTEMS

Concept of feedback: open loop and closed loop systems. Feedback in electrical and mechanical systems. Mathematical models of systems and linear approximations. Transfer functions of linear systems, block diagrams and signal flow graphs. Sensitivity, control of transient response, disturbance signals. Time domain performance: steady state errors, performance indices. Stability related to s-plane location of the roots of the characteristic equation. Routh-Hurwitz criterion. Graphical analysis techniques: root locus, frequency response as polar plots and Bode diagrams. Closed loop frequency response and Nichols chart. Prerequisite: 16-362.

16-414 FEEDBACK CONTROL SYSTEMS II (3,0) 3

Time domain analysis of control systems. Analysis of higher order control systems. Compensation by root locus, frequency domain, and algebraic techniques. Truxal's and Chen's method for compensation. A.C. carrier and digital control systems. Prerequisite: 16-413.

16-416 ELECTRONIC AMPLIFIER CIRCUITS II (3,0) 3

An integrated treatment of the analysis and design of electronic amplifiers. Typical amplifier specifications such as noise figure, intermodulation, intercept point, power dissipation, frequency response, gain, compression point, and VSWR are discussed in detail. Emphasis is than placed on the choosing of electronic devices and circuit configuration based on amplifier and system design objectives. Prerequisite: 16-366.

16-417 ABSOLUTE AND SYMBOLIC PROGRAMMING I (3,0) 3

An introduction to absolute and symbolic programming and coding fundamentals. Typical digital computer organization; breakdown of function blocks including arithmetic unit, control unit, memory and input-output structure. Computer word formats: single and double precision, floating point and instruction words. Machine instructions and methods of execution. Symbolic coding. Address modification, index registers and looping. Subroutines, calling sequences and utility routines. Input-output programming. Table processing techniques. Programs will be run by students on the Electrical Engineering Department's HP2116B computer. Prerequisite: 16-328.

16-420 COMPUTERS IN ENGINEERING ANALYSIS AND DESIGN II (3,0) 3

An advanced programming course which considers the digital computer as a tool for solving significant engineering problems. The course is based on a specific area in engineering which will be selected from such topics as large scale circuit analysis, system simulation, optimization techniques, etc. Typical algorithms related to the specific topic will be studied. User-oriented programs or subroutine packages will be developed as a class project. Prerequisite: 16-328.

16-425 WAVE SHAPING AND GENERATION I I (3,0) 3

Principles and methods of wave shaping and wave generation using active and passive elements. Steady-state switching characteristics of electronic devices. Clipping, clamping, and switching circuits. Logic circuits. Prerequisite: 16-366.

16-426 WAVE SHAPING AND GENERATION II II (3,0) 3

Bistable, monostable, astable multivibrators, comparators and sweep circuits. Negative resistance devices and switching circuits. Sampling gates, counting and timing, synchronization frequency division. Prerequisite: 16-425.

16-429 NETWORK SYNTHESIS I (3,0) 3

Review of linear system analysis methods: consideration of natural frequencies for impedance-by-inspection techniques. Tellegen's theorem: general reciprocity relation and driving-point impedance characteristics. Positive-real functions: definitions and tests. Hurwitz polynomials and Sturm tests. Properties of LCT, RCT, RLT, and RLCT one-ports with Cauer, Foster, and Brune network realizations. Partial-pole removals and introduction to transfer function realizations. Prerequisites: 16-362, 92-315.

16-434 ACTIVE NETWORK THEORY I (3,0) 3

A study of active inductorless networks with emphasis on design and implementation. The course will cover the following subject: Approximation Theory, the Operational Amplifier, the gyrator, the negative impedance converter, analysis of basic second order active building blocks, the biquad building block, the state variable filter, and the design of filters. The course will include a design project. Prerequisite: 16-366.

16-435 through 16-438 SPECIAL TOPICS IN ELECTRICAL ENGINEERING I, II (3,0) 3

Study of undergraduate subjects related to electrical engineering not otherwise included in curriculum. Topics selected from recent developments in the field of electrical engineering.

16-439 INTRODUCTION TO COMMUNICATION THEORY I (3,0) 3

An introduction to the study of the time-domain and frequency-domain characteristics of signals arising in communication systems. Fourier analysis, correlation functions, power and energy density spectra. The time and frequency characteristics of thermal noise voltages. Amplitude modulation, frequency modulation, digital modulation. Signal-t-noise ratio, and noise figure. Prerequisite: 16-362.

16-440 COMMUNICATION SYSTEMS II (3,0) 3

Analysis of the performance and operating characteristics of communications systems, including radar. Review of spectral characteristics of baseband, AM, and FM signals. Signal characteristics of modulators, amplifiers, mixers, and demodulators. Noise figure and noise temperature. Noise and phase distortion characteristics of transmission lines. Systems characteristics of antennas-gain, directivity, equivalent source temperature. Characteristics of antenna-to-antenna links. Signal transmission characteristics of radio propagation paths from radio frequencies to microwave frequencies. Study of examples including cable and microwave repeater systems, ratio, and radar. Prerequisites: 16-362, 16-461.

16-443 ELECTRICAL POWER SYSTEMS I I (3,0) 3

An intermediate course in analysis and operation of electrical power systems using mathematical techniques including applied calculus and matrix algebra. Consideration will be given to topics such as network reductions and representation of lines, generators, and transformers, network topology and transform methods. Emphasis is placed upon the bus impedance matrix and its corresponding rake equivalent circuit for use in power network problems. Symmetrical components will be introduced with application to polyphase systems. Prerequisite: 16-202 or 16-361.

16-444 ELECTRICAL POWER SYSTEMS II II (3,0) 3

A continuing use of symmetrical components and the rake equivalent circuit will be further applied to the analysis of polyphase systems. Particular emphasis will be given to fault studies in three-phase systems. An introductory study, using selected numerical methods, will be directed to load flow, economic dispatch, unit commitment, and system stability. Prerequisite: 16-443.

16-445 ANALOG DEVICES AND TECHNIQUES I (3,0) 3

A survey of analog devices and techniques, concentrating on operational amplifier design and applications. Operational amplified design is studied in order to reveal the limitations of real operational amplifiers and to develop an understanding of specifications. Representative applications are covered, including: amplifiers, differential and instrumentation amplifiers, summers, integrators, analog computation, nonlinear circuits, signal processing circuits and waveform generation circuits. Prerequisite: 16-366.

16-451 MODERN OPTICS I (3,0) 3

Maxwell's equations in vacuum, as well as in non-linear, non-isotropic media. Reflection and refraction, interference and diffraction, Helmholtz equation, polarization, Brewster's angle and modes (TE, TM, TEM). Basic theory of various laser types; coherence and partial coherence. Introduction to quantum mechanics. The role of noise in optical systems. Examples of optics engineering; fiber optics and optical logic gates, optical tracking, optical detection, masers, holography and medical electronics applications. Prerequisites: 16-363 and 16-461.

16-461 ELECTOMAGNETIC THEORY II I (3,0) 3

Extension of 16-360 to time varying fields. Topics include: Faraday's law, displacement current, Maxwell's equations, plane waves, Poynting's theorem, skin depth, transmission line theory, Smith chart. Prerequisite: 16-360.

16-462 ANTENNAS II (3,0) 3

An introduction to the properties of individual antennas and arrays of antennas. Retarded potentials, dipoles of arbitrary length, radiation pattern, gain, directivity, radiation resistance. The loop antenna. Effects of the earth. Reciprocity, receiving antennas, effective length and area. Arrays, colinear, broadside, endfire. Array systhesis. Mutual coupling. T.V. antennas, log periodic and Yagi arrays. Radiation from apertures, the waveguide horn antenna.

16-465 DIRECT ENERGY CONVERSION I (3,0) 3

Review of first and second law of thermodynamics; thermoelectric, photoelectric, and thermionic conversion. Fuel cells, magnetohydrodynamic and electrogasdynamic conversion Fusion. Nuclear fission, reactor theory, reactor control and operation. Prerequisite: 16-355.

16-500 PRINCIPLES OF ELECTRICAL ENGINEERING I or II (3,0) 3

Fundamental definitions and circuit laws with applications. Important network theorems such as superposition and Thevenin's theorem. First order transients and forced responses. Diode, transistor, and FET large-signal models. Pulse and digital circuits including transistor and FET switches, waveshaping schemes, multi-vibrators and logic gates. Switching-speed, propagation times, fan-in and fan-out characteristics of DTL and TTL logic families.

Although this course is primarily intended for students whose undergraduate major was in an engineering or scientific discipline other than electrical engineering, it is also recommended for students who have received their Bachelor of Science in Electrical Engineering degree more than five years ago and who feel the need for review of electrical principles. In any case, graduate credit will be given only to M.S.C.P. and M.S.S.E. degree candidates not holding a B.S.E.E., while those with the B.S.E.E. degree must substitute a three (3) credit-hour elective to satisfy the requirements for the M.S.C.P. degree. Prerequisite: B.S. in Engineering or Science.

16-503 SOLID-STATE PHYSICAL ELECTRONICS I I or II (3,0) 3

Introduction to the behavior of solid-state electronic devices from the viewpoint of modern physics; review of classical mechanics and Maxwell's equations. The Bohr atom, wave-particle duality, wave packets, Schroedinger's equation, band theory of solids, electrons and holes. Mechanical and acoustical properties of solids, semi-conductor behavior. Prerequisite: 16-360.

16-504 SOLID-STATE PHYSICAL ELECTRONICS II I or II (3,0) 3

Continuation of 16-503. Semiconductor devices: Schottk diodes, p-n junction devices, junction transistors, field-effect transistors, photo-diodes, varactors. Electro-optic devices, thermoelectric devices, electro-luminescent diodes and laser diodes. Magnetism and magnetic devices. Prerequisite: 16-503.

16-505 MICROWAVE ELECTRONICS I I or II (3,0) 3

Design oriented course dealing with Solid State Active Microwave Devices. Amplifiers, Oscillators, Switches, Modulators, Mixers, Limiters. Realization of Microwave Systems through MIC (Microwave Integrated Circuit) Techniques. Computer Analysis Aids of Microwave Designs. Prerequisite: 16-461.

16-507 ELECTROMAGNETICS I I or II (3,0) 3

Maxwell's Equations, Poynting;s Theorem, Boundary Value Problems in Electrostatics and Electrodynamics, Green's Functions, Retarded Potentials, Reflection and Refraction of Plane Waves, skin effect, Wave Guides. Prerequisite: 16-461.

16-508 ELECTROMAGNETICS II I or II (3,0) 3

Wave Propagation in Plasma and Ferrites, Space Charge Waves, Microwave Circuits, Elementary Antenna Theory, the Dipole, Loop, and Simple Arrays, Huyghen's Principle and Radiation from Apertures. Prerequisite: 16-461.

16-509 LINEAR SYSTEMS ANALYSIS I or II (3,0) 3

Classical solution of linear systems described by differential equations. Duals, analogs, and electromechanical systems. System function, step and impulse response, and initial conditions. Time-domain convolution. Fournier analysis, series, and integral: impulse method for obtaining transforms. Laplace transforms: evaluation and properties. Complex variable theory: complex differentiation and Cauchy-Riemann equations. Complex integration: Cauchy's theorem and Cauchy's integral formulas. Taylor and Laurent series and the residue theorem inverse Laplace transforms. Introduction to Z-transforms. Prerequisite: 16-362.

16-513 LINEAR CONTROL THEORY-ANALYSIS I or II (3,0) 3

Transicent performance of linear feedback control systems for determination inputs, using state variable formulation. Block diagram representation and analysis of typical systems. Development and application of Routh-Hurwitz, Nyquist, and root-locus criteria for stability considerations. Comparison of several compensation configurations for both static and dynamic performance criteria, including the effects of specific disturbances. Consideration of controllability and observability. Prerequisite: 16-362.

16-515 NONLINEAR CONTROL SYSTEMS I or II (3,0) 3

Analytic and numerical methods for the analysis and design of nonlinear control systems. Phase plane, describing function, the methods of Lyapunov and Popov and other non-linear analysis techniques are treated. Prerequisite: 16-413 or 16-513.

16-517 OPTIMAL CONTROL SYSTEMS I or II (3,0) 3

A study of the analysis and design of optimal control systems by dynamic programming, calculus of variations, and Pontryagin's Method. Prerequisite: 14-413 or 16-513.

16-519 DISCRETE DATA CONTROL SYSTEMS I or II (3,0) 3

The sampling process, reconstruction of sampled signals, transforms, inverse Z-transforms and flow graph representation of digital systems. The state variable approach to discrete data systems, time solutions by state varible methods. Stability of discrete data systems. Introduction to optimal control of discrete data systems. Prerequisite: 16-413 or 16-513.

16-520 DISCRETE MATHEMATICS FOR COMPUTER ENGINEERS I or II (3,0) 3

Numerical algorithms fundamental to scientific computation. Elementary discussion of error, polynomial interpolation, numerical integration, solution of non-linear equations, function minimization by the method of steepest descent, numerical solution of systems of ordinary differential and difference equations with applications in the study of continuous and discrete-time dynamical systems. Prerequisite: 16-328.

16-521 AUTOMATA STUDIES I or II (3,0) 3

Mathematical foundation of automata, including probabilistic logics, neuron analog, Turing machines, and learning theory. Prerequisite: 16-412.

16-522 COMPUTER PROCESSING OF NON-NUMERICAL DATA I or II (3,0) 3

Character strings, character and character substring searches; lists, their storage structures and uses; trees, tree searches, and storage concepts; compiling, polish strings, translating from infix to postfix and prefix, conversion to machine code. Prerequisite: 16-328 or permission of instructor.

16-523 COMPILER STRUCTURES I or II (3,0) 3

Translators and interpreters for programming languages. Syntax of programming languages, syntax directed compilation. Parsing techniques: operator precedence, top down, bottom up and reductive strategies. Intermediate forms and symbol tables. Generation and optimization of machine code. Error handling: detecting and correction. The run time environment, storage allocation. Prerequisite: 16-563 or permission of instructor.

16-524 PROGRAMMING LANGUAGES I or II (3,0) 3

An introduction to the formal concepts of programming languages including specification of syntax and semantics. Examination of programming languages (FORTRAN, ALGOL, APL) and string processing languages (SNOBOL). Concepts such as information binding, data storage and mapping and basic control structures are discussed. Prerequisite: 16-328.

16-525 SIMULATION TECHNIQUES I or II (3,0) 3

A study of modern analog, digital and hybrid techniques for the simulation of continuous and discrete systems and process. The student is expected to study a number of practical engineering systems through the use of simulation techniques on available analog, hybrid and digital computers. Prerequisites: 16-328, 16-445.

16-528 ADVANCED NETWORK ANALYSIS I or II (3,0) 3

Network topology, generalization of circuit equations on loop, nodal, and mixed basis, using matrix algebra. Linear independence and choosing network variables. Tellegen's theorem, reciprocity, and the properties of passive networks. Quadratic forms. Methods of handling mututal inductance, dependent sources, gyrators, and the like with Thevenin's therorem, superposition, and other network theorems. Impedence by inspection and the relationship between the natural frequencies of a system and the poles and zeros of the impedence and admittance functions. The phase and magnitude relationships of various filters with precorrection for loss effects, using frequency transformations and Hilbert transforms. Butterworth and Chebyshev filters with magnitude and frequency scaling. Properties and interconnections of two-terminal pair networks and Barlett's bisection theorem. Prerequisite: 16-362.

16-529 NETWORK SYNTHESIS I or II (3,0) 3

A review of natural frequencies and analysis techniques; complex variable topics such as conformal mapping, maximum modulus theorem, and Laurent series. Tellegen's theorem. Positive real (p.r.) functions developed from four different viewpoints, including reflection coefficients. Methods for testing p.r. functions; Hurwitz test, Sturm test, and residue tests. Quadratic forms and the testing for p.r. matrices. Properties of the driving point and transfer immittances of LCT, RCT, and RLT networks, Cauer and Foster network realizations, partial pole removals. Cauer transformations. RLCT Brune realizations. Prerequisite: 16-362.

16-530 NETWORK SYNTHESIS II I or II (3,0) 3

RLCT driving-point synthesis methods of Darlington, Bott-Duffin, Miyata and Fialkow-Gerst. Transfer synthesis methods of Darlington, constant-resistance lattice, RC ladder. Approximation problems using Butterworth functions, dissipation and predistortion techniques. An introduction to active network synthesis. Prerequisite: 16-529.

16-531 ACTIVE NETWORK SYNTHESIS I or II (3,0) 3

Definition and discussion of active network elements such as controlled sources, impedance converters, and impedance inverters. Synthesis techniques using the negative impedance converter, the gyrator, and the infinite gain amplifier will be discussed. The application of the various active elements to modern active filter design will be emphasized. Prerequisite: 16-529.

16-537 INTRODUCTION TO BIO-MEDICAL ENGINEERING I or II (3,0) 3

A survey of the use of engineering methods in the life sciences. Topics covered include instrumentation techniques and devices, computer diagnosis of disease, computer aided data analysis, telemetry, ultrasonic techniques, artificial organs, prosthetic devices, biological modeling and simulation. Necessary biological background information is introduced as needed. Prerequisite: 16-366.

16-539 BIOLOGICAL SYSTEMS I or II (3,0) 3

A discussion of the application of modern control theory to the study of biological systems. Modeling and simulation techniques are emphasized. Necessary biological background information is introduced as required. Prerequisites: 16-413, 16-445, 16-537.

16-543 THEORY OF COMMUNICATIONS I or II (3,0) 3

Introduction to information transmission. Representation of deterministic signals in time and frequence domains. Relationship between correlation and power or energy spectra. Introduction to statistical properties of noise. Thermal and shot noise, signal-to-noise ratio, noise figure, and noise temperature. Comparative analysis of continuous and discrete modulation systems; analysis of AM, FM and varous pulse modulation methods (PAM, PPM, PCM) in the presence of noise. Corequisite: 16-509.

16-545 CODING THEORY I or II (3,0) 3

Concepts and recent developments in the use of codes for error control in data handling systems. Encoding and decoding procedures and their implementation in computational algorithms and hardware organizations are investigated in detail. Corequisite: 16-577.

16-547 STATISTICAL COMMUNICATION THEORY I or II (3,0) 3

A study of statistical communications problems. Particular topics include the description of signals and noise as stochastic processes, optimum smoothing and prediction and statistical decision theory. Prerequisite: 92-584.

16-548 INFORMATION THEORY I or II (3,0) 3

A study of the probabilistic measure of information transmitted by information sources, the determination of the information handling capacity of communication channels and fundamental coding theorems. Prerequisite: 16-362.

16-549 INTRODUCTION TO LASERS AND MASERS I or II (3,0) 3

A first course on lasers and masers and their application. Classical electromagnetic theory as well as introductory Quantum Mechanics serve to provide the proper background to engineering students interested in industrial and scientific laser applications. Typical topics include interferometry, liquid crystals and fiber optics, harmonic generation and holography. Prerequisite: 16-362, 16-461 or equivalent.

16-551 ELECTRO-OPTICS I or II (3,0) 3

Principles of optical propagation as described by the Fresnel-Kirchhoff Integral and the Rayleigh integral, concept of transform theory as applied to optical imaging systems, transform theory of conjugate focal plane of lenses in coherent optical systems, geometrical optics as described by Newtonian lens formulae and principles of holographic three-dimentsional wavefront reconstruction. Prerequisites: 16-362, 16-461.

16-561 COMPUTER ORGANIZATION AND DESIGN I or II (3,0) 3

A critical examination of the organization of present day digital computers from both the software and hardware points of view. Computer design with hardware-software trade-off. Comparison of instruction sets, their hardware implementation. Examination of the input-output structures of selected examples. Multi-processing and parallel processing. Detailed examination of a large system and of several mini-computers. Students are expected to simulate certain aspects of the example computers on available digital computers. Prerequisites: 16-411, 16-417.

16-562 MICROPROGRAMMING I or II (3,0) 3

Microprocessor applications such as digital communication systems, point of sale terminals and process control systems are discussed. The use of programming aids, such as assemblers, editors, compilers, loaders, and debuggers for microprogram development. Software user library subroutine applications. Examples of microprocessor programming of real problems are studied. Prerequisite: 16-417.

16-563 SYSTEM PROGRAMMING I or II (3,0) 3

The definition of system programming as programming in a multi-user environment. Programming with and for interrupts. Reentrant programming, pure procedures. Communication between program modules. Nested calls, the push-down stack. Recursive program calls. Reentrant interrupt programming. Activation records and program sharing. Memory allocation by absolute and relocatable loaders. Macro languages, macro processes and introduction to assemblers and macro assemblers. Prerequisite: 16-417.

16-564 OPERATING SYSTEMS I or II (3,0) 3

The resources of a large computer system. Sequential and concurrent processes in large digital computers. Design objectives: Program sharing, Multi-processing, Memory-sharing and protection. Process communications and critical processes in operating systems. Scheduling. Paging, Segmenting and swaping strategies. Time sharing and multiple-task operating systems. Design and simulation of operating system behavior. Operating system performance evaluation. Prerequisite: 16-417.

16-571 INTRODUCTION TO RADAR SYSTEMS I or II (3,0) 3

Introduction to both pulsed and C.W. radar systems. Detection of radar echoes in noise. The radar equation and its use in estimating performance of a radar system. Estimation of range, direction and velocity of targets. Moving target indicators (MTI). Pulse compression and other advanced techniques. Dscussion of elements of practical radar systems.

16-574 INTRODUCTION TO DIGITAL SYSTEM DESIGN I or II (3,0) 3

A review of combinatorial and sequential circuit concepts at both the bit and register levels, number systems, binary adders, shift registers, and memories. The definition of a basic set of control operations and data modules that are used to develop a register-transfer-level language which is used to flowchart and document design algorithms. Computer-assisted simulations, using SIMRIM, are conducted to assist in an evaluation of the costs, performance, and adaptability of each design algorithm. Applications include asynchronous processing, parallel processing, stacks, queues, microprocessing, special purpose processors, and microcoded processors. Prerequisites: 16-411, 16-417.

16-575 DIGITAL SUBSYSTEM DESIGN I or II (2,2) 3

An overview of the design process developed in 16-574 with emphasis on developing algorithms at the register transfer level, decompostion of these algorithms into detailed RTL flowcharts showing registers, transfer paths, control and timing paths. Selected flowcharts are converted to a detailed wiring diagram and wire-wrap testing and study. A hardware term project is required of each student, constructed from the available register transfer module family along with a complete report detailing the scope and purpose of the algorithm. Prerequisite: 16-574.

16-577 STATE VARIABLE ANALYSIS OF SYSTEMS I or II (3,0) 3

Algebra of matrices, vector spaces, and linear transformations. Calculus of matrices, matrix functions and the solution of differential and difference equations as formulated by the state variable characterization of systems. A consideration of canonical forms for computer simulation. Prerequisite: 16-362.

16-581 ELECTRODYNAMICS I or II (3,0) 3

The main focus of this course is the transient analysis of electromechanical devices, including electromechanical transducers and ac dc machines. Topics covered include stored electric and magnetic energy, electric and magnetic forces, dynamic models of electromechanical devices, solution of differential equations to obtain equations of motion, driving point impedances, transfer functions for linear devices, and methods of approximation for non-linear devices. Applications covered include magnetic transducers, piezoelectric transducers, transicent analysis of power systems, and the formulation of mathematical models of servomechanism components. Prerequisite: 16-355.

DEPARTMENT OF INDUSTRIAL TECHNOLOGY (COURSE PREFIX 20)

20-105 INTRODUCTION TO ENGINEERING DESIGN I (2,3) 3

A course to introduce students to industrial practice in design graphics. Topics include graphs, orthographic projection, sectioning, limit dimensioning, gear trains, cams and fasterners. A mechanical design problem completes the semester's work.

20-201 STRUCTURE OF METALS I (2,2) 3

A practical study of the structure of metals and the methods used to improve their properties for industrial applications. This course includes selection, heat treatment and fabrication of metals as well as their preparation and applications for use under extreme environmental conditions.

20-202 INDUSTRIAL COMPUTER SCIENCE II (3,0) 3

An introduction to the use of computers in industry by programming in COBOL and FORTRAN languages. Ten programs are required to be designed and run by the students. Problems include I/O, a min-max, branching, arrays, matrices, plotting, subprograms and a major inventory type problem.

20-204 MECHANICS FOR TECHNOLOGY I (3,2) 4

An introduction to solid and fluid mechanics. Topics include: force and moment equilibrium, friction, torque, horsepower, stress, strain, deflection, Reynold's number, fluid flow and pressure variation. Theoretical concepts are verified by laboratory experiments. Prerequisite: 95-151.

20-301 MODERN MATERIALS II (2,2) 3

This course is a continuation of the study of materials. It covers the third general classification of engineering materials, ceramics, and the structural potpouri of all engineering materials, composites. The study of ceramics will stress the way these properties enter into the selection of ceramic materials for industrial applications. The study of composites will serve as a review of all materials and their interactions upon being combined into one material. A third topic will be the joining processes used in manufacturing. Prerequisites: 20-201, 26-211.

20-303 MECHANICAL POWER TRANSMISSIONS II (2,2) 3

An introduction to the design or selection of mechanical elements used in the transmission of power in industrial equipment. Elements considered include shafts, pulleys, gears and gear trains, bearings, clutches, brakes and springs. Prerequisites: 20-204 or equivalent.

20-304 TOOL AND FIXTURE DESIGN II (1,4) 3

This course introduces students to specialized production tools- jigs, fixtures, and gages. Methods of locating and clamping work pieces to be machined are discussed in lectures. Laboratory drawing work involves the layout and design of jigs and fixtures, and the proper selection of standard parts for these tools. Prerequisite: 20-105 or equivalent.

20-305 MODERN MANUFACTURING PROCESSES II (2,3) 3

Students participating in this course will gain both a theoretical and a practical understanding of modern manufacturing processes. These include numerical control machining, preparation of N.C. tapes, electric discharge machines, casting, fastening methods, and assembly techniques. Product design as related to manufacturing will be considered. Prerequisite: 20-171 or equivalent.

Laboratory experiences will include experiments with numerical control as well as field trips to various manufacturing concerns.

20-306 SEMINAR I II (3,0) 3

A seminar course for industrial technology juniors actively pursuing an industrial internship program.

20-307 FLUID POWER CONTROLS I (2,2) 3

Laboratory experiences and lectures on the elements of hydraulic and pneumatic power systems, and the automatic control of these systems. Systems elements studied are actuators, valves, power sources and accessories. Control systems studied are pneumatic, electronic and fluidic logic. Electrical solenoid and relay control circuits are designed.

20-401 THERMAL ENGINEERING I (3,0) 3

The principles of thermodynamics and its applications. The basics of heat transfer and psychrometic properties. Heating, ventilating, air conditioning and controls. A term project is required. Prerequisite: 95-151 or equivalent.

20-402 MANUFACTURING OPERATIONS II (1,4) 3

This course is organized so that students can design the manufacturing process and fabricate a product for small quantity production. Accompanying lectures cover pertinent subject areas such as: forcasting, plant layout, materials handling, pert/cost, product evaluation and equipment selection. Several plant trips and outside speakers are usually scheduled. Prerequisite: 20-203 and 16-901.

20-403 SEMINAR II I (3,0) 3

A seminar course for I-T seniors actively pursuing an industrial internship program.

20-406 SEMINAR III II (3,0) 3

A seminar course for I-T seniors actively pursuing an industrial internship program.

20-407 INSTRUMENTATION & PROCESS CONTROL I (3,2) 4

An introduction to process control system technology. Liquid level, rate of flow, pressure and temperature measuring devices and their characteristics. R-C of system components. Integral, dead-time and first order lag processes. Control modes. Bode diagrams and frequency response. Prerequisite: 16-901.

20-414 INDUSTRIAL ECONOMIC MANAGEMENT I (3,2) 3

Analysis of available alternatives in equipment, plant and materials purchasing or leasing. Economic feasibility analysis of industrial projects including depreciation techniques, break-even analysis, benefit-cost techniques, replacement, present worth and rate of return analysis.

20-416 QUALITY STANDARDS II (3,0) 3

Selected regulatory and non-regulatory standards are examined from the viewpoint of consumer-vendor relationships and legal requirements. Manufactured and natural products are considered. The possible influence of certain Federal requirements such as tariffs are examined. Prerequisite: permission of instructor.

20-476 STATISTICAL QUALITY CONTROL I (3,0) 3

A study of the statistical and administrative techniques relative to the maintenance of product quality at defined levels. Sampling plans for variables and attributes are considered from the viewpoint of consumer-vendor relationships and economics. Prerequisite: 92-383 or equivalent.

DEPARTMENT OF MECHANICAL ENGINEERING (COURSE PREFIX 22)

22-201 GRAPHICS I (1,0) 1

The technique of communicating engineering information and concepts by means of orthographic drawings, pictorial views and sketches. Charts, graphs, gear design, fundamentals of descriptive geometry.

22-205 INTRODUCTION TO ENGINEERING DESIGN II (2,3) 3

Lecture topics include orthographic projection, dimensioning, detailing, standard parts and procedures used in the design of gear reducers, welded structures, and castings. The students "vocabulary of mechanical design" is developed by laboratory drawing exercises involving cams, gears, shafts, bearing, etc. A term design project is assigned to provide the student with a comprehensive experience in layout designs during the latter half of the term. Prerequisite: 22-271.

22-206 MECHANICAL ENGINEERING LABORATORY I II (3,0) 1

A series of laboratory experiments which supplement the simultaneous classroom activities in mechanics of materials and thermodynamics. Prerequisites or Corequisites: 22-220, 22-242.

22-211 MECHANICS I I (3,0) 3

The application of Newton's Laws to engineering problems involving statics. The free body diagram method is heavily emphasized. Topics covered include: vector algebra; force; moment of a force; couples; static equilibirum of rigid bodies; truss analysis; friction; centroids; the concept of stress at a point, and Mohr's Circle for stress. Prerequisites: 92-132 or 92-134; 96-141.

22-212 ENGINEERING MECHANICS II (4,0) 4

Intended as a one-semester, terminal course with emphasis on engineering aspects of mechanics. Vectors. Mechanical equilibrium, rigid and deformable solids, stress and strain under various loading conditions, elastic moduli and mechanical properties of materials. Kinematics. Dynamics via Newton's second law including momentum and energy forms. Applications include rigid body motion, vibrations and electric analogue, central force moton, colliding particles. Prerequisites: 96-144; 92-232 or 92-234 (concurrently)

22-215 ANALYTIC MECHANICS I I (3,0) 3

Statics: vectors, rigid body equilibrium, forces and force systems, friction, moment and moment of inertia. Mechanics of deformable body in equilibrium: stress and strain, elastic moduli and mechanical properties of materials. Applications to simple tension, compression, and shear loadings, shafts in torsion, pressure vessels. Prequisites: 92-132 or 92-134; 96-141 (Primarily for CN and PL students)

22-216 ANALYTIC MECHANICS II II (3,0) 3

Continuation of 22-215. Elastic deformation of solid bodies under various loading conditions, including beam theory, and buckling theory for loaded columns. Kinetics and Dynamics. Newton's second law including momentum and energy methods. Applications to rigid body motion, central force motion, vibrations, and colliding particles. Prerequisite: 22-215. (Primarily for CN, and PL students).

22-220 MECHANICS OF MATERIALS I II (3,0) 3

Stress and deformation analysis of bodies under axial, torsional, flexural and combined loading. Composite materials. Energy methods. Buckling, Prerequisites: 92-231 or 92-233; 22-211.

22-228 MECHANICS OF DEFORMABLE BODIES II (4,0) 4

Statics and strength of materials. Vectors, forces and couples, friction, free-body diagrams, stress and strain. Analysis of structures under axial, flexural, torsional and combined loading. Prerequisite: 92-233.

22-242 THERMODYNAMICS I, II (3,0) 3

A detailed development of the First and Second Law as applied to an open and closed system in steady and unsteady flow. Thermodynamic properties of pure substances, condensible vapors and the perfect gas. The concept of entropy, reversibility, irreversibility, and availability. Energy conversion cycles. Prerequisites: 92-231 or 92-233; 96-144.

22-271 MACHINE TOOL LABORATORY I (1,1) 1

Lectures, demonstrations and laboratory experiences in pattermaking, foundry practice, casting, fabricating and forming. Lectures also cover surface finish and measurements along with a basic introduction to numerical control and electrical discharge machining.

22-307 MECHANICAL ENGINEERING LABORATORY II I(0,3) 1

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics, fluid mechanics, and materials science. Prerequisites or Corequisites: 22-309, 22-382, 22-395.

22-308 MECHANICAL ENGINEERING LABORATORY III II (0,3) 1

A series of laboratory experiments which supplement the simultaneous classroom activities in dynamics systems and heat transfer. Prerequisites or Corequisites: 22-343, 22-354.

22-309 DYNAMICS I I (3,0) 3

Vector development of kinematics of a particle with respect fo fixed and moving coordinate systems of one, two, and three dimensions. The dynamics of a particle, system of particles, and rigid bodies. Angular momentum and the inertial properties of rigid bodies. Energy, impulse and momentum. Prerequisites: 92-232 or 92-234; 22-211, 96-144.

22-315 APPLIED MECHANICS I (3,0) 3

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and the introduction to dynamics. Prerequisites: 92-132 or 92-134; 96-141. (Primarily for IM students)

22-320 MACHINE DESIGN I II (2,3) 3

The principles of mechanics and commonly used theories of failure are applied to the analysis and design of typical machine elements which are subjected to various loading conditions. Laboratory work requires the solution of comprehensive machine design problems that illustrate the close relationship between analysis and synthesis in design. Methods of writing clear and coherent design reports are emphasized. Prerequisites: 22-220, 22-309.

22-343 HEAT TRANSFER I, II (3,0) 3

Theory and application of steady and transient heat conduction in solids. Mathemetical development of hydrodynamic and thermal boundary layer theory. Forced convection, natural convection, heat exchangers. Development of thermal radiation with application to heat exchange between non-black bodies. Prerequisites: 22-242 or 22-347; 22-382.

22-344 HEAT AND POWER II (3,0) 3

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment. Prerequisites: 92-132 or 92-134. (Primarily for IM students)

22-347 ELEMENTS OF THERMODYNAMICS AND HEAT TRANSFER I, II (3,0) 3

A study of the First and Second Law of thermodynamics with application to system and changes of state. Heat transfer by conduction, convection, and radiation. Steady and unsteady cases. Prerequisites: 92-231 or 92-233; 96-144. (Primarily for CE and EE students)

22-354 DYNAMIC SYSTEMS II (3,0) 3

Unified approach to the modeling of simple mechanical, electrical, thermal and fluid systems. Transient and steady-stare response of first and second order systems via classical and Laplace transform techniques. Prerequisites: 92-301, 22-309.

22-372 STRENGTH OF MATERIALS II (3,0) 3

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses. Prerequisite: 22-315. (Primarily for IM students)

22-377 ELEMENTS OF MATERIALS SCIENCE I (2,0) 2

Introduction to mechanical, electrical, thermal and chemical properties of materials. Various tests to which materials are subjected to determine such properties as tensile and compression strength, toughness, hardness etc. Crystal structures and deformation of metals, strain hardening, solid solutions and heat treatment. Basic aspects of powder metallurgy, corrosion along with a study of both ferrous and non-ferrous metals. (Primarily for IM students)

22-382 FLUID MECHANICS I, II (3,0) 3

Development of basic fluid mechanical relations; continuity, momentum, and Bernoulli equations. Emphasis on control volume approach to problem solving. Hydrostatics. Boundary layer concept, separation, Reynolds number, fluid dynamic drag. Angular momentum principles with application to turbomachinery. Prerequisite: 22-211; Corequisite: 92-301.

22-395 MATERIALS SCIENCE I (3,0) 3

Materials for use in engineering applications are presented in terms of their general mechanical behavior, the thermodynamics of their structures, and their properties as related to their atomic and crystalline structure. The specific differences and similarities between metals, polymers and ceramics are emphasized. Prerequisites: 84-122, 96-144.

22-407 MECHANICAL ENGINEERING LABORATORY IV I (3,0) 1

A series of laboratory experiments which supplement the simultaneous activities in thermodyamics and automatic controls. Prerequisite: 22-497; Corequisite: 22-474.

22-409 SENIOR PROJECT I I (3,0) 1

Direct engineering experience in planning, executing and reporting of an individual project selected by the student in consultation with the M.E. Staff Members. The first term is devoted to problem definition, solution synthesis and design analysis. Prerequisite: senior status.

22-410 SENIOR PROJECT II II (0,6) 2

A continuation of 22-409. The second term is devoted to trade off and optimization, construction, testing, evaluation and reporting. Prerequisite: 22-409.

22-413 GAS DYNAMICS I or II (3,0) 3

Extension of basic fluid mechanical equations of motion to inviscid, compressible flows. One-dimensional, steady flows with area change. Fanno and Rayleigh flows. Normal and oblique shocks. Prandtl-Meyer expansion. Prerequisites: 22-242, 22-382.

22-417 DYNAMICS II I or II (3,0) 3

Generalized coordinates and lagranges' Equations. Solutions to both linear and nonlinear one degree-of-freedom mechanical systems, phase plane techniques. Multi-degree-of-freedom systems. Prerequisite: 22-354.

22-419 NONDESTRUCTIVE EVALUATION TECHNIQUES I or II (3,0) 3

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitation of each. Particular emphasis is placed upon the analysis and correlation of the interactions of these energy forms with material properties and processes. Flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical and metallurgical properties. Prerequisite: senior status.

22-422 MACHINE DESIGN II I or II (2,3) 3

A continuation of 22-320. Laboratory problems emphasized aspects of the overall design process; the use of the layout tool in machine design; the compromise between theoretical and practical considerations; optimum design criteria. Prerequisite: 22-320.

22-428 KINEMATIC MECHANISM SYNTHESIS I or II (3,0) 3

Methods of designing mechanisms to convert given input motions to required output motions. Topics include function generation, coupler curves, postion coordination, and spatial mechanisms. Problems are designed for solution by graphical methods, by computer solution using the analog and digital computers.

22-429 FLUID POWER CONTROLS I or II (2,2) 3

This subject involves the designing of hydraulic and pneumatic systems from load analysis and performance specifications. Elements of fluid power systems; actuators, valves, pulps and compressors, and accessories, Boolean algebra, pneumatic, electronic and fluidic logic systems and electrical relay-solenoid controls.

22-452 NUMERICAL ANALYSIS I or II (3,0) 3

Iterative solution of algebraic equations, convergence, error estimate, order of iteration, accelerating convergence. Interpolation, difference, error estimates. Numerical differentiation, extrapolation to the limit. Numerical integration, Newton-Cotes formulas, error estimate, Romberg integration. Second-order partial differential equations, finite difference representation, error, parabolic equations, accuracy, stability. First order, ordinary differential equations, predictor/corrector methods, Adams-Bashford methods, higher order equations. Student determines course grade by developing computer solutions to problems in fluid mechanics, dynamics, and heat transfer using numerican techniques studied in course. Prerequisite: 92-232 or 92-234, 92-361.

22-462 ENGINEERING SYSTEMS ANALYSIS I or II (3,0) 3

A study of the methods used in engineering analysis with emphasis on the basic types of underlying mathemetics. Successful engineering models of equilibrium, eigenvalue, and propagation problems are developed in matrix form, and applied to contemporary problems of an interdisciplinary nature. Prerequisite: senior status.

22-472 EXPERIMENTAL STRESS ANALYSIS I or II (3,0) 3

The determination of stresses and strains in loaded members by experimental techniques including photoelasticity, birefringent coatings, holography, Moire methods, brittle coatings, analogies, strain gages. Prerequisite: 22-220.

22-473 MECHANICS OF MATERIALS II I or II (3,0) 3

The state of stress at a point; theories of failure by yielding; energy methods; ineleastic buckling; buckling of tubes; shear center, unsymmetrical bending; curved flexural members; torsional resistance in non-circular sections. Prerequisites: 92-301, 22-220.

22-474 THERMODYNAMICS APPLICATIONS I (3,0) 3

Application of basic laws of thermodynamics to power and refrigeration cycles. Mixtures of ideal gases, and air-water vapor mixtures with application to air conditioning. Combustion. Flow of a compressible fluid through a nozzle. Mach number, choiking, normal shock. Prerequisites: 22-242 and 22-382.

22-475 PHYSICAL METALLURGY I or II (3,0) 3

A study of the theories discussed in material science as they apply specifically to mechnical deformation of materials: yielding, creep, fracture, viscoeleastic and plastic deformation, etc.. The effects of thermal and mechanical treatments on the above properties are also considered in detail. Prerequisites: 22-295.

22-477 COMPOSITE MATERIALS I or II (3,0) 3

The course devotes attention to various types of composite materials used in modern industries. Both particulate and fiber reinforced materials are studied from fabrication, application, analysis and design view-points. Prerequisites: 22-220, 22-295.

22-480 ADVANCED PROJECTS IN SYSTEMS AND DESIGN I or II (1,6) 3

For the student desiring to carry on substantial projects of his own choosing in the areas of engineering design, systems or automatic controls. Project to be arranged on an individual basis in consultation with instructor. Prerequisites: senior status.

22-483 AERODYNAMICS I or II (3,0) 3

Fundamentals of subsonic aerodynamics. Atmosphere models. Circulation, downwash, and three-dimensional wing theory. Airfoil data, and lift and drag of aircraft components. Introduction to aircraft performance calculations. Prerequisite: 22-382.

22-484 JET PROPULSION AND TURBOMACHINERY I or II (3,0) 3

Air breathing jet propulsion. Thrust, Propulsion efficiency. Thermodyamics of Brayton cycle, component efficiencies, thermal efficiency. Comparison of propjets, turbojets, and turbofans. Detailed performance calculation of turbofan engine using measured data and high temperature gas properties. Turbo-machinery, velocity triangles, Euler's turbomahcinery equation. Axial flow compressor, rotating stall and surge stability compressor map. Axial flow turbines. Exhaust nozzles. After burners. Engine component matching. Future trends in jet propulsion. Prerequisites: 22-242, 22-382, 22-413 or 22-474.

22-485 MECHANICAL ENGINEERING PROBLEMS IN OCEANOGRAPHY I or II (3,0) 3

Fluid mechanics of ocean waves. Tidal waves, surface waves, wind driven waves, Sea State classification of waves. Ocean currents. Tides, Motion of ocean platforms and buoys. Forces on submerged mooring cables, cable configurations. Dynamics of liquid spills on water. Prerequisites: 22-382, 22-309.

22-488 ENVIRONMENTAL CONDITIONING I or II (3,0) 3

The control of thermal environment within enclosed spaces including transfer of heat and work energy. Refrigeration cycles, heating humidification, dehumidification and mixtures. Design of conditioned spaces. Prerequisites: 22-242 or 22-347.

22-497 AUTOMATIC CONTROLS SYSTEMS I (3,0) 3

Concept of open loop and feedback control systems. Use of block diagrams and transfer functions for system representation. Transient and steady-state response using frequency response and root locus techniques. Stability and compensation. Consideration of hydraulic pneumatic, electromechanical and thermal control systems. Prerequisite: 22-354.

22-521 MECHANICAL BEHAVIOR OF MATERIALS I or II (3,0) 3

An examination of deformation mechanisms in solids and the study of such topics as brittle and ductile modes of fracture, fatigue, creep, viscoelasticity, diffusion, friction and war using actual case studies of failures. Prerequisite: 22-475.

22-530 ULTRASOUND, A NONDESTRUCTIVE EVALUATION METHOD I or II (3,0) 3

Propagation characteristics of ultrasound are developed and analyzed to indicate usefulness as a nondestructive method of evaluation. Equipment for generation, detection and display. Scientific and engineering applications using velocity and attenuation measurements are stressed.

22-531 ADVANCED THERMODYNAMICS I or II (3,0) 3

A comprehensive treatment of the classical first and second law. Availability, criteria of equilibrium, heterogeneous systems, mixtures and solutions, chemical equilibrium. Introduction to statistical methods as applied to evaluation of thermodynamic properties.

22-534 TRANSPORT PROCESSES I or II (3,0) 3

Diffusive and convective transport of mass, momentum and energy. Forced convection in laminar and turbulent flows. High velocity flows, ablation, condensation, drying, combustion of solids and liquids.

22-535 ADVANCED HEAT TRANSFER I or II (3,0) 3

Heat conduction: analytical and numerical solutions. Thermal stresses. Laws of thermal radiations. Combined modes of heat transfer. Heat transfer in the environment and in biological systems. Thermal pollution.

22-536 COMBUSTION I or II (3,0) 3

Dynamics of premixed and diffusion flames. Ignition and extinction. Burning of liquid and solid fuels. Radiation from flames. Fire problems.

22-541 ADVANCED FLUID MECHANICS I or II (3,0) 3

Basic equations of incompressible flow. Flow in open channels. Waterwaves. Flow over airfoil; lift and drag. Creeping flow and theory of lubrication Boundary layer. Introduction to the statistical theory of turbulence. Experimental techniques.

22-542 ADVANCED GAS DYNAMICS I or II (3,0) 3

Equations of motion for inviscid, compressible fluid, One-dimensional steady flow with area change, friction, heat transfer and combustion. Shock waves. Unsteady flows and wave phenomena. Similarity characteristics, small disturbances, approximation procedures.

22-544 ACCOUSTICS I or II (3,0) 3

Fundamentals of the propagation of sound in fluids and stuctures. Included will be a development of the basic concepts and equations and the application of these to special topics such as physiology, underwater accoustics and sound.

22-546 ENERGY CONVERSION I or II (3,0) 3

Concepts of thermodynamics pertaining to energy conversion; irreversible thermodynamics. Solid-state phenomena involved in conversion processes; energy forms, equations of states and energy fields. Selected topics in direct energy conversion systems.

22-548 ADVANCED TOPICS IN AERODYNAMICS I or II (3,0) 3

Application of aerodynamice principles to three or four of the following topics: helicopter rotor aerodynamics (including propellers and wind turbines), rocket trajectories, orbital mechanics, aircraft performance analysis, stability and control. Topics varied from year to year to suit current student interest. Prerequisite: 22-483 or permission of instructor.

22-551 CONTINUUM MECHANICS I or II (3,0) 3

Stress and deformation in a continuum in tensor notation. Fundamental laws of mechanics and thermodynamics. Application to elastic viscous and viscoelastic substances.

22-552 STRUCTURAL APPLICATION OF COMPOSITE MATERIALS I or II (3,0) 3

Study of constitutive relationships for anisotropic materials and application of these materials to structural elements such as beams, plates and shells. Problem areas considered include bending, buckling, and vibrations.

22-553 FINITE ELEMENT ANALYSIS I or II (3,0) 3

A review of matrix algebra and calculus to develop the finite element equations in structural and thermal systems. Review of stress, strain and constitutive equations of solids. Develop mass and stiffness matrices for truss, frames 2D and 3D solids. A large finite element computer program (SAPIV) will be used to solve problems in structural mechanics. Non steady heat conduction problems will also be studied using finite element techniques.

22-554 THEORY OF ELASTICITY I or II (3,0) 3

Formulation of the problem of elastic equilibrium. Torsion and flexure of prismatic bars, contact stresses, plane stress, plain strain and stress concentration. Prerequisite: 22-551.

22-556 THEORY OF THE INELASTIC CONTINUUM I or II (3,0) 3

Development of the constitutive equations governing inelastic (anelastic, viscoelastic, plastic and visco-plastic) deformations. Theorems and boundary value problems as applied to inelastic continua. Prerequisite: 22-551

22-558 PLATES AND SHELLS I or II (3,0) 3

Variational methods are utilized to derive the plate and shell equilibrium equations including nonlinear effects and inertia terms. Solutions to bending, buckling and vibration problems are obtained for rectangular and circular plates. The membrane theory of shells as well as the general theory is investigated and solutions are obtained for a variety of practical shell problems.

22-562 ADVANCED DYNAMICS I or II (3,0) 3

Dynamics of mechanical systems by use of direct and variational methods. Three-dimensional rigid body dynamics and vibrations of lumped parameter and continuous systems. Non-linear and self-excited oscillations. Stability.

22-564 STRUCTURAL DYNAMICS I or II (3,0) 3

Review of matrix operations, development of the equations of motion of a single and multi degree of freedom systems. Development of stiffness, mass and damping matrices. Condensation of equations by stiffness condensation and GUYAN reduction. Modal analysis techniques to encouple equations of motion. Direct integration of the motion equations. Discussion of proportional and non-proportional damping. Applications using computer programs such as EIGENV and SAPIV to solve problems in structural dynamics.

22-572 DYNAMIC SYSTEMS AND CONTROL I or II (3,0) 3

Classical and modern approach to system dynamics. System representation in state variable form Multiple input-multiple output systems. State equations for electromechanical systems using the state function of Lagrange. System response and the state transition matrix. Numerical methods and simulation. Introduction to digital control.

22-581 ENGINEERING ANALYSIS I or II (3,0) 3

A study of the methods used in engineering analysis. Topics include matrix methods, variational methods, finite differences, fourier series, and Ritz and Galeskin's methods for solving differential equations. Problem examples include systems encountered in solid mechanics, heat transfer, and fluid mechanics.

22-582 MATRIX METHOD IN ENGINEERING MECHANICS I or II (3,0) 3

Development of matrix methods of analysis as applied to engineering mechanics. Methods include determining eigenvalues and eigenvectors using direct and iterative techniques; solution of large sets of algebraic equations using direct reduction techniques such as CROUT, CHOLESKY and GAUSS-DOOLITTLE schemes; FORTRAN programs involving the methods will be written for the digital computer; problems will involve development of mass and stiffness matrices for structural systems involving vibrations and stability.

DEPARTMENT OF NUCLEAR ENGINEERING (COURSE PREFIX 24)

24-204 SEMINAR IN NUCLEAR ENGINEERING II (1,0) 1

Discussion of fission and fusion as power sources, historical development, current types of nuclear reactors; future developments; practical examination of the UL Reactor system. Phelps.

24-301 REACTOR PHYSICS I I (3,0) 3

Nuclear forces and energy; binding energy; the fission process; nuclear reactors; radioactivity, neutron cross sections; diffusion theory; the slowing down of neutrons; Fermi age Theory. Prerequisites: 80-201, 80-202. Filippone.

24-302 REACTOR PHYSICS II II (3,0) 3

The unreflected reactor; one-group, two group and multigroup diffusion theories; reflector savings; homogeneous reactor systems; heterogeneous reactor systems; slightly-enriched, water-moderated lattice systems; fast breeder reactors; reactor kinetics, reactor temperature coefficients; fission product poisoning, reactor control and operations. Prerequisite: 24-301. Filippone.

24-401 NUCLEAR REACTOR ENGINEERING I I (3,0) 3

Review of current and projected types of nuclear power reactors, including breeders; energy production and removal; heat transfer in fuel elements and shields; heat transfer to non-boiling and boiling liquids; core hydraulics. Particular emphasis is placed on pressurized-water and boiling-water reactors. Prerequisite: 24-302. Brown.

24-402 NUCLEAR REACTOR ENGINEERING II II (3,0) 3

Thermodynamic cycles of power reactors, including gas-cooled reactors; thermal stress analysis in reactor components; elements of nuclear power economics; introduction to nuclear fusion and fusion reactors. Prerequisite: 24-401. Brown.

24-403 REACTOR OPERATION AND LICENSING I (2,2) 3

Start-up and operation of nuclear plants; regulations, procedures, and measurements. Staffing requirements. The licensing process, including the roles of the USNRC, the licensee, and the public; review of safety analysis reports and environmental impact statements, technical specifications, and codes. Each student goes through a precritical reactor checkout, critical approach, and various reactor operational measurements in the University of Lowell Reactor. Prerequisite: permission of instructor. Phelps & Reactor Staff.

24-404 NUCLEAR REACTOR DESIGN II (3,0) 3

A group design project in which the class participates in the overall design of a nuclear power plant system, integrating the requirements of reactor physics, control heat transfer, thermodynamics, fuel cycle, economics, safety, siting and radiological and environmental effects. Each member of the class will be responsible for a particular aspect of the design. Prerequisites: 24-301, 24-401.

24-416 INTRODUCTION TO FUSION RESEARCH I or II (3,0) 3

Fusion reactions: the Coulomb barrier. Phase space: moments of the distribution function: charge, current density, and pressure tensor. The Saha Equation. The Maxwell Equations. Elementary Plasma theory. Possible approach to controlled fusion; methods of plasma confinement. Energy balance equation for a plasma, radiation losses, operational conditions, and utilization of themonuclear neutrons. Prerequisite: permission of instructor. Martin.

24-495 SPECIAL NUCLEAR PROBLEMS I (3,0) 3

Special problems in nuclear engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication. Prerequisite: permission of department chairperson, and instructor.

24-496 SPECIAL NUCLEAR PROBLEMS II (3,0) 3

Continuation of 24-495 for a second semester. Prerequisite: permission of department chairperson and instructor.

24-505 REACTOR PHYSICS I I (3,0) 3

Review of nuclear physics, cross sections, fission; the neutron transport equation; diffusion theory; critical reactors; reactor kinetics; variational methods; perturbation theory. Prerequisite: permission of instructor. Filippone.

24-506 REACTOR PHYSICS II II (3,0) 3

Numerical methods; reactor control, rod worths, self-shielding, fuel depletion, fission product poisoning; the multi-group methods; slowing-down calculations, Fermi age theory. Prerequisite: 24-505. Filippone.

24-507 REACTOR ENGINEERING I I (3,0) 3

Analysis of fission energy generation and transport in a reactor. Analytical and numerical analysis of heat transfer in nuclear reactors; fluid dynamics. Prerequisite: permission of instructor. Brown.

24-508 REACTOR ENGINEERING II II (3,0) 3

Continuation of 24-507. Analysis of reactor power cycles and detailed discussion of the characteristics of different reactor types. Prerequisite: 24-507. Brown

24-509 FAST REACTORS I (3,0) 3

General characteristics of fast reactors. Breeding cycles and plutonium production; neutron balance, breeding ration and doubling time. Simplified methods for fast reactor calculation. Kinetics, control and safety of fast reactors; sodium void and Doppler coefficients. Engineering consideration and design concepts in large. Prerequisite: 24-302 or 24-506. Brown.

24-510 NUCLEAR FUEL CYCLE AND POWER ECONOMICS II (3,0) 3

Discussion of the nuclear fuel cycle, including preirradiation, irradiation and post-irradiation steps encountered by the fuel in a nuclear reactor. Evaluation of the components of the cost of electricity produced by a nuclear reactor. Prerequisite: 24-302 or 24-506. Brown.

24-511 CRITICALITY AND NUCLEAR REACTOR SAFETY II (3,0) 3

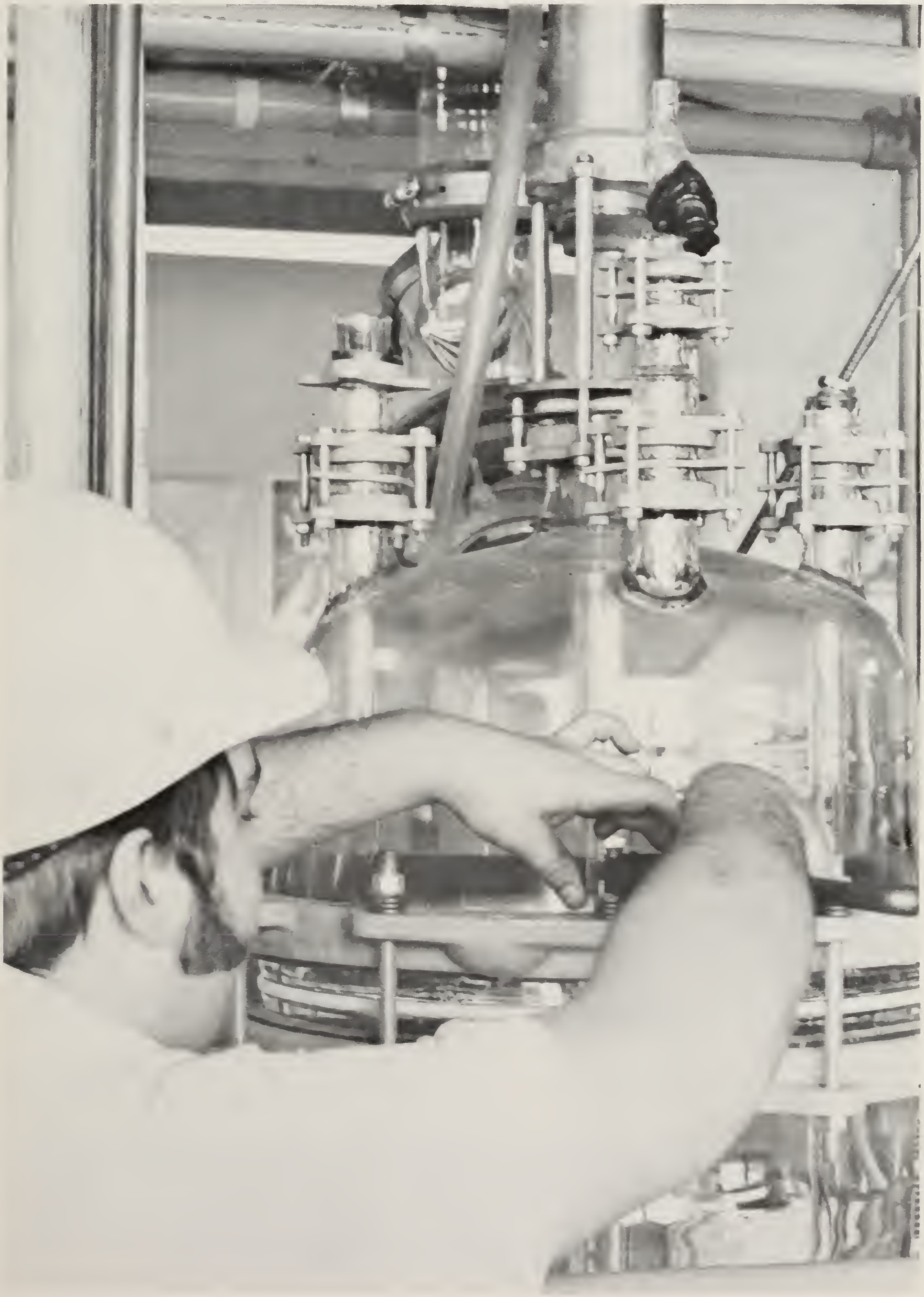
Consideration of safe practices in transportation, storage, handling, and use of fissionable materials. Effects of moderators, reflectors, and geometrics in thermal, epi-thermal, and fast assemblies.Natural and engineered safeguards are discussed. Prerequisite: permission of instructor. Phelps.

24-515 CONTROLLED NUCLEAR FUSION I (3,0) 3

Survey of energy resources. Methods of obtaining energy from fusion reactions. Electromagnetic theory applicable to plasmas. The production, heating and confinement of plasmas. Instabilities and energy processes. Prerequisite: permission of instructor. Martin.

24-525 NUMERICAL METHODS OF REACTOR ANALYSIS I (3,0) 3

Matrix algebra, difference equations and matrix iterative techniques. Applications involving the neutron diffusion and heat conduction equations. Description of the Sn, Monte Carlo, and Response Matrix methods. Prerequisite: permission of instructor. Filippone.



DEPARTMENT OF PLASTICS ENGINEERING (COURSE PREFIX 26)

26-201 POLMERIC MATERIALS I I (3,0) 3

An intensive study of the many generic classes of polymeric materials: review of important raw materials, polymerization theory and practice, methods of manufacture, and correlation of polymer structure with engineering properties. Review of marketing principles and property/performace characteristics.

26-202 POLYMERIC MATERIALS II II (3,0) 3

A continuation of Polymeric Materials I. Emphasis is on the thermoplastic resins and especially the engineering polymerics. Comprehensive review of product performance and its relationship to basis design principles as representative manufacturing systems. Discussion of polyblends with emphasis on related polymer chemistry, inter- and intra-molecular bonding, and fundamental processing characteristics. Outline of recent developments in thermal extreme polymeric systems. Prerequisite: 26-201 or permission of instructor.

26-204 PROCESS CONTROL SYSTEMS II (3,0) 3

Basic principles of control systems used with plastics processing equipment. Included are instrumentation, signal conditioning, data acquisition, feed back control, process monitoring, and data reduction. Prerequisite: 96-142 or 96-148 or permission of instructor.

26-211 PLASTICS MATERIAL SCIENCE II (2,2) 3

Discussion of the historical development of polymeric materials, related classification systems, and methods of manufacture. Survey of the more prominent resin families with particular emphasis on the engineering plastics. Review of end-use applications with respect to pricing, processing, and performance. (Primarily for Industrial Technology majors.)

26-215 PLASTICS PROCESSING LABORATORY I I (0,3) 1

A laboratory course to study polymer processing methods. Experiments are designed so that the student will understand the theory of polymer conversion techniques by the interaction between process variables and materials. Some of the conversion methods studied are extrusion, injection molding, blow molding, thermoforming, compounding and mixing.

26-216 PLASTICS PROCESSING LABORATORY II II (0,3) 1

A continuation of 26-215.

26-272 INTRODUCTION TO PLASTICS TOOLING OPERATIONS II (0,3) 1

The technique of communicating engineering information and concepts by means of orthographic drawings, pictorial views and sketches. Lectures on design, drawings, dimensioning, fasteners, gears, cams, bearings and manufacturing techniques. Lectures, demonstration and laboratory experience in material processing. The student becomes familiar with the purpose and operation of industrial machine tools for turning, grinding, mill, shaping, and electrical discharge machining. Laboratory experiences in sketching, layout and design drawing.

26-301 POLMETIC MATERIALS III I (2,0) 2

Analytical review of the chemical satellites incorporated in base polymers to modify processing characteristics and inherent/physical properties. Theoretical review of reinforcements, chemical and physical compatibility of additives, plasticizer theory, thermal and oxidative stabilization/degradtion mechanisms, flame retardant actions, and other important additives such as colorants, biocides, blowing agents, antistatic treatments, and impact modifers/processing aids. Prerequisites: 26-201, 26-202 or permission of instructor.

26-302 POLYMERIC MATERIALS IV II (2,0) 2

Discussion of the compounding techniques employed in the materials development of specialty formulations. Survey of materials for molding compounds, reinforced plastic/composite systems, film and sheeting, and applied polymer science topics including adhesives, elastomers, coatings and fibers. Strong development of fundamentals involved in non plastics applications of polymers. Prerequisites: 26-301 or permission of instructor.

26-314 FLUID POWER SYSTEMS II (3,0) 3

Statics and dynamics of Newtonian fluids. Flow in closed conduits. Measurement of fluid flow. Fluid power machinery and control systems.

26-315 PLASTICS PROCESSING LABORATORY III I (0,3) 1

Laboratory instruction of a more advanced nature in the processing and fabrication of plastics materials. A continuation of the processing laboratory sequence but with the emphasis on student designed experiments.

26-316 PLASTICS PROCESSING LABORATORY IV II (0,3) 1

A continuation of 26-315.

26-373 PLASTICS MOLD ENGINEERING I I (2,2) 3

Course work entails the introduction to the fundamentals of plastics mold and die engineering with the objective to develop an overall appreciation of the mold engineer's job. Emphasis is placed on an intradisciplinary approach to mold engineering to include the interrelationships of polymeric materials processing, plastics product design; mold and die design/construction, and design communications. Laboratory consists of the actual design of a mold or mold components with emphasis on mechanical drawing in design communications.

26-376 PLASTICS MOLD ENGINEERING II II (2,2) 3

Course work entails indepth exploration of the fundamental principles of plastics mold and die engineering to include cavity design, material feed "systems", rheology and orientation within the mold, ejection systems, parting surfaces, mold "action", and thermodynamic considerations. Emphasis is placed on injection and "prototype" mold design. Laboratory consists of case study approach to the lecture materials, and the design and construction of prototype molds. Prerequisite: 26-373.

26-401 PLASTICS PROCESS ENGINEERING I I (3,0) 3

A study of the fundamental principles of polymer processing, i.e. the conversion of polymeric materials into useful articles. Correlation between process variables, material characteristics and part design are studied to determine the functional relationship between them.

26-402 PLASTICS PROCESS ENGINEERING II II (3,0) 3

A continuation of 26-401.

26-403 PHYSICAL PROPERTIES OF POLYMERS I (3,0) 3

Introduction to basic mechanical properties of polymers as linear viscoelastic materials. Concepts of creep, stress relaxation, and superposition principles emphasized. Dynamic mechanical behavior, interrelations between various properties, electrical behavior, miscellaneous mechanical properties, optical properties. Prerequisite: senior status.

26-405 METHODS OF POLYMER CHARACTERIZATION I (2,0) 2

Survey of the leading physicochemical techniques for characterizing the composition, structure, and morphology of polymer molecules and polymer systems. Prerequisite: senior status.

26-406 POLYMER STRUCTURE II (3,0) 3

The fundamental relationships between molecular structure, properties and end-use applications of plastics materials will be explored in detail. Molecular structural features include chemical compostion, molecular size and flexibility, intermolecular order and binding, and supermolecular structure. Properties include processability, mechanical, accoustic, thermal, electrical, optical and chemical properties price, and balance of properties. Applications include rigid solids, flexible solids, foams, film, and non-plastic applications. Prerequisite: permission of instructor.

26-407 PLASTICS INDUSTRY ORGANIZATION I (3,0) 3

Economics of producing plastics raw materials and converting them into end products, from research and development to plant construction, operation, and marketing. Market analysis of plastics production, processing, and consumer patterns; commercial development, sales, and technical service. Organization of the plastics industry for research and development, specialty and commodity production, profit and growth. Prerequisite: permission of instructor.

26-409 SENIOR RESEARCH IN PLASTICS I (1,6) 3

Individual research projects in plastics chemistry, properties, processing, products, and industry organization. Students will review the existing literature, obtain materials and equipment, plan and carry out research programs and submit final reports for publication. Prerequisite: permission of instructor.

26-410 SENIOR RESEARCH IN PLASTICS II (1,6) 3

Continuation of 26-409.

26-411 PLASTICS SEMINAR I (1,0) 1

Informal discussions based on literature study conducted by the individual of topics in or related to Plastics Engineering.

26-412 PLASTICS SEMINAR II (1,0) 1

Continuation of 26-411.

26-413 SENIOR PROJECTS I (0,2) 1

Assignment of senior projects designed to develop the student's ability to organize and conduct investigations of materials performance and processing techniques.

26-414 SENIOR PROJECTS II (0,2) 1

Continuation of 26-413.

26-415 PHYSICAL PROPERTIES LABORATORY I I (0,3) 1

Measurement of mechanical properties in tension, compression, shear, and flexure; dielectric constant and dissipation factor; thermal behavior under stress; melt rheology.

26-416 PHYSICAL PROPERTIES LABORATORY II II(0,3) 1

Continuation of 26-415.

26-417 PLASTICS PROCESSING TECHNIQUES I (1,2) 1

A study of the manufacturing techniques used in the plastics industry. Emphasis will be placed on extrusion, injection molding, blow molding, compounding and thermoforming. Correlation between the properties of a material and its processability will be investigated. Not open to students majoring in Plastics Engineering.

26-420 PLASTICS IN ELECTRICAL ENGINEERING II (3,0) 3

Elective course in applied polymer science as related to current/potential electrical engineering applications. Attention devoted to polymeric materials and reinforced plastics, principal physical properties, processing methods and manufacturing consideration, and testing methods. Review of practical applications with emphasis on price, processability, and performance.

26-431 SURVEY OF MAN MADE FIBERS AND FIBER STRUCTURES I (3,0) 3

Discussion of the basic problems encountered in the man made fiber industries, including fiber and fiber structure properties, processing, utilization and various aspects of current research. Recent advances and projected developments.

26-445 METHODS OF EXPERIMENTAL ANALYSIS I (3,0) 3

Methods of efficient design and analysis of scientific and industrial processing experiments. Classical versus factorial experiments, statistical distributions and statistical inference, single and multifactorial analysis, interaction, correlation and regression.

26-451 SELECTED TOPICS IN PLASTICS I (3,0) 3

Topics in various fields of plastics. Content may vary from year to year so that students may by repeated enrollment acquire a broad knowledge of contemporary plastics.

26-452 SELECTED TOPICS IN PLASTICS II (3,0) 3

Continuation of 26-451.

26-502 NEW PLASTICS PROCESSING TECHNIQUES II (3,0) 3

Critical examination of new plastics processing techniques appearing in the research literature and being commercialized in the plastics industry. Prerequisite: permission of instructor.

26-503 MECHANICAL BEHAVIOR OF POLYMERS I (3,0) 3

Mechanical properties of bulk polymers as a class of engineering materials. Linear Viscoelasticity and its application to relaxation, creep, dynamic and stress/strain response phenomena. The principles of time/temperature superposition, the relation between the chemical/physical structure of polymers and their utilization as plastics, elastomers, and fibers. The effect of molecular weight distrbution, branching, cross-linking, order and crystallinity on bulk properties. Statistical mechanical formulation of rubber elasticity. Ultimate and/or failure behavior of polymeric materials and their interpretation on the molecular level. Prerequisite: permission of instructor.

26-504 PROCESSING, MORPHOLOGY, AND PROPERTIES II (3,0) 3

Effect of processing conditions on polymer fine structure and morphology, and the attendant changes in mechanical and physical properties. Theoretical interpretation of the interrelationships involved. Prerequisite: 26-503.

26-509 PLASTICS PROCESSING THEORY I I (3,0) 3

Principles of heat transfer, rheology, mixing, crystallization, and chemical reactions involved in the processing of plastics, and their applications to plastics process engineering. Prerequisite: permission of instructor.

26-510 PLASTIC PROCESSING THEORY II II (3,0) 3

Continuation of 26-509. Prerequisite: permission of instructor.

26-511 MULTIPHASE POLYMER SYSTEMS I (3,0) 3

Compatibility of polymer blends, block and graft copolymers. Morphology of semicompatible systems, and theoretical relationships between structure and properties. Practical systems in development and production. Prerequisite: permission of instructor.

26-512 PLASTICS FOAMS II (3,0) 3

Preparation, structure, and properties of plastics foams. Practical systems in development and production. Properties, applications, and markets for plastics foams and products made from them. Prerequisite: permission of instructor.

26-513 NEW PLASTICS MATERIALS I (3,0) 3

Critical examination of the new plastics materials appearing in the research literature and being field-tested for commericalization in the plastics industry. Prerequisite: permission of instructor

26-516 COMPOSTITE MATERIALS II (3,0) 3

The potential of composties as a class of materials, and the uniqueness of the mechanical/physical properties realizable. Fundamental concepts underlying those properties, with particular emphasis on fibrous reinforced plastics. Survey of matrices, reinforcements, and prediction of composite properties from a knowledge of the properties and topology of constituent materials. Factors affecting ultimate strength and fatigue behavior. Prerequisite: permission of instructor.

26-518 PRODUCT DESIGN II (3,0) 3

Theoretical principles and sound engineering practice involved in the design of new end products made from polymers applying the total systems approach to the balance between product design, choice of materials, and process technique, as they affect competitive choice for commercial success. Prerequisite: permission of instructor.

26-521 POLYMERIZATION ENGINEERING I (3,0) 3

Engineering design of equipment and plants for polymer production. Processes for production of each of the major commercial polymers. Prerequisite: permission of instructor.

26-523 MATERIAL AND ENERGY BALANCES IN PLASTICS PROCESSING I (3,0) 3

Batch and continuous processes. Dimensional analysis. Thermodynamic properties of thermoplastics. The use of enthalpy diagrams in energy balances. Heat capacity, sensibe heat, heat of fusion, and heat of reaction. Intensive and extensive properties of plastics. Phase changes and transitions in thermoplastics. Prerequisite: permission of instructor.

26-524 PROCESS ANALYSIS, INSTRUMENTATION, AND CONTROL II (3,0) 3

Industrial instruments for measurement and control of plastics processes. Design of experiments. Analysis of plastics forming operatings. Dynamic testing techniques. Automatic plastics process control. Modeling and process simulation in extrusion and injection molding. Data acquisition systems. Prerequisite: permission of instructor.

26-527 KNITTED STRUCTURES I (2,3) 3

Study of the principles of knitting and the mechanisms required to develop various fabric structures. Prerequisite: permission of instructor.

26-528 NON-CONVENTIONAL FIBER STRUCTURES II (2,3) 3

Non-woven materials and unusual fiber structures such as needle-punched, stitch bonded and ultra-sonic welded structures. Problems are assigned for laboratory evaluations and written reports as well as oral presentations are required. Prerequisite: permission of instructor.

26-532 ADHESIVES II (3,0) 3

Theories of adhesion. Materials and compounding. Methods of application. Adherends and applications. Prerequisite: permission of instructor.

26-533 COATINGS SCIENCE AND TECHNOLOGY I (3,0) 6

Polymers, fillers, solvents, and additives used in coatings. Methods of polymerization, formulation, application, and testing. Substrates and application. Prerequisite: permission of instructor.

26-534 COATINGS SCIENCE AD TECHNOLOGY II (3,0) 6

Continuation of 26-533.

26-535 RUBBER I (3,0) 3

Polymerization and compounding of the commercial elastomers. Properties and test methods. Leading applications and methods of processing. Prerequisite: permission of instructor.

26-537 ENGINEERING PROPERTIES OF PLASTICS I (3,0) 3

Theoretical basis and practical significance of the mechanical, thermal, electrical, optical, and chemical properties of plastic materials. Importance of engineering properties in material development and selection and in product design. Prerequisite: permission of instructor.

26-536 RHEOLOGY II (3,0) 3

Fundamental principles of the flow of polymers in bulk, melt, solution, and latex form. Flow instabilities associated with viscoelastic flow. Prerequisite: permission of instructor.

ORGANIZATION AND GOVERNANCE

The College of Engineering is organized into seven departments and is administered by a dean. Each departments is responsible for developing its course offerings and programs of study and the engineering faculty, as a whole, is responsible for all academic policies of the College. The Academic Standards Committe is responsible for enforcing the academic standard of the College and also serves as a review body for suspended students seeking readmission with probationary status.

ACADEMIC STANDARDS COMMITTEE

Mr. Arthur Ainsworth, Industrial Technology
Dr. Roger Baumann, Electrical Engineering
Dr. Aldo Crugnola, Plastics Engineering
Dr. William Hogan, Dean
Dr. Norwood Keeney, Jr., Chemical Engineering
Dr. William Moeller, Civil Engineering
Dr. Eugene Niemi, Jr., Mechanical Engineering
Dr. James Phelps, Nuclear Engineering
Mr. James Powers, Electrical Engineering

INDUSTRIAL ADVISORY COMMITTEES

The engineering faculty and the several departments are assisted in formulating professional curricula by the following advisory committees.

Electrical Engineering

Mr. Joseph F. Alibrandi, Raytheon Company
Dr. Walter S. Baird, Baird-Atomic, Inc.
Mr. W. Clare Brooks, Andover
Dr. Martin Schilling, Raytheon Company
Mr. Paul G. Yewell, Yewell Associates, Inc.

Paper (Chemical Engineering)

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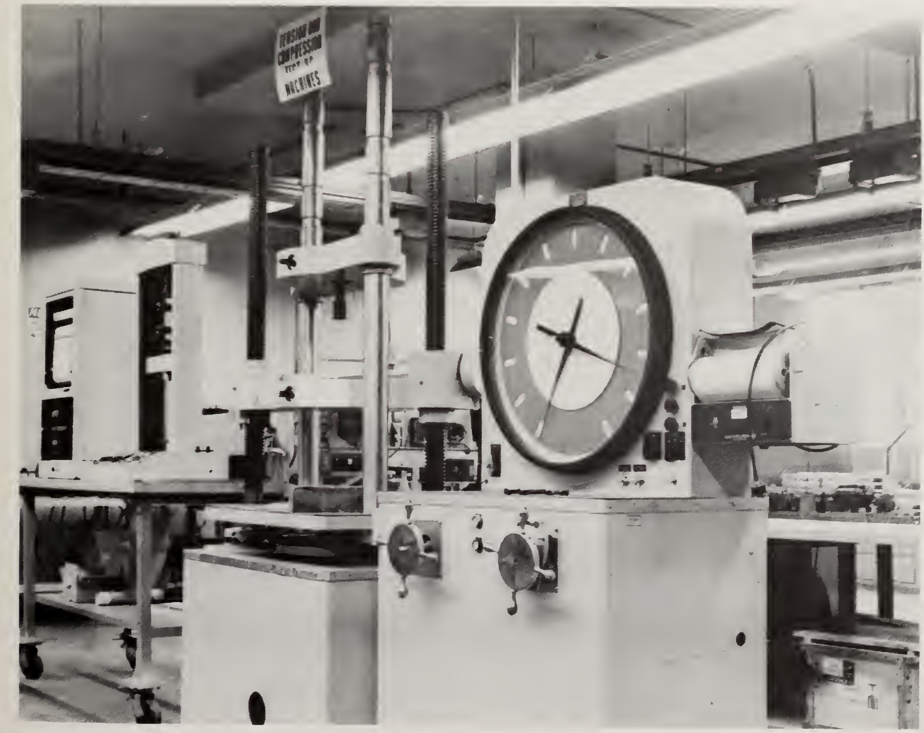

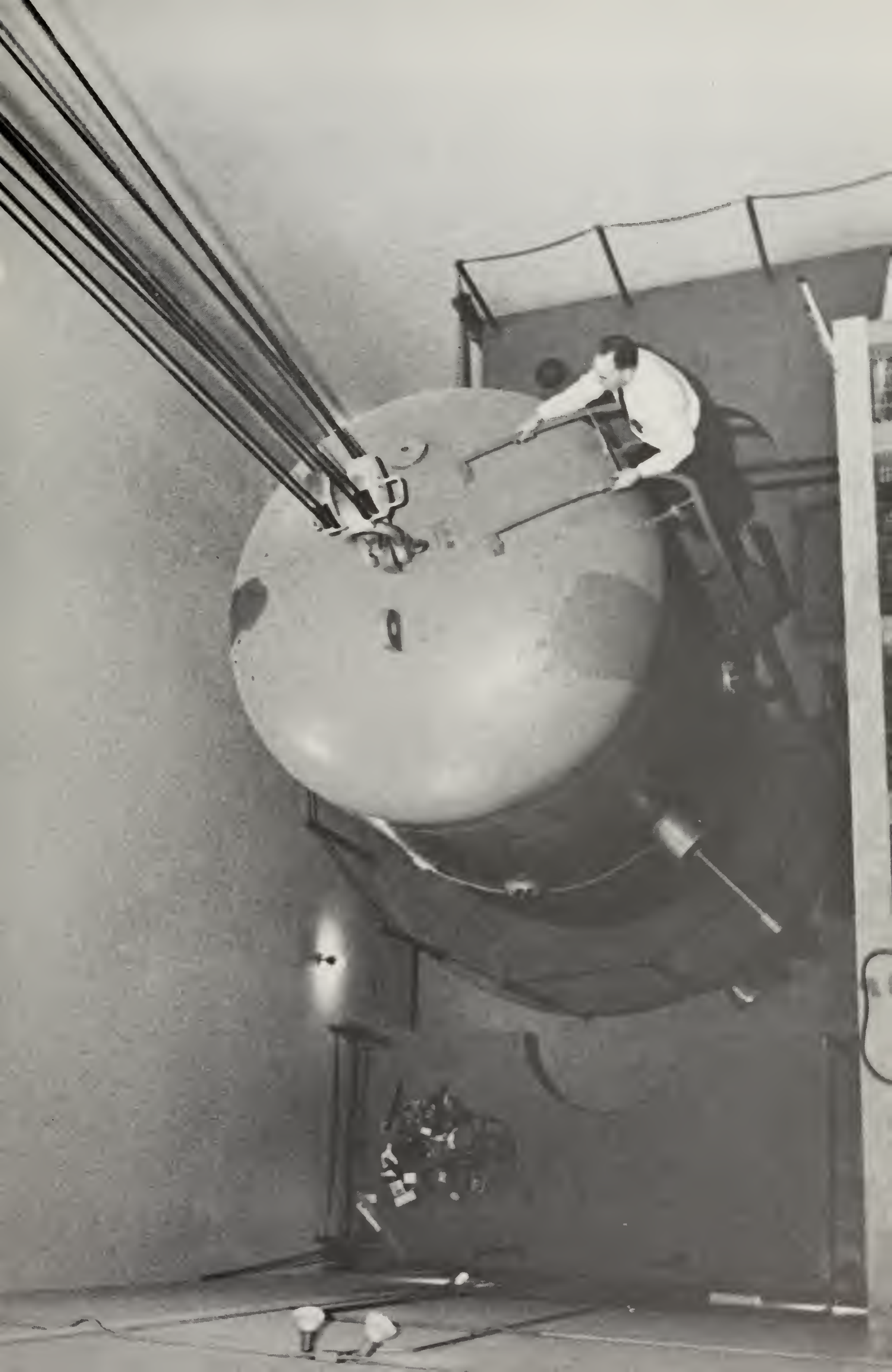

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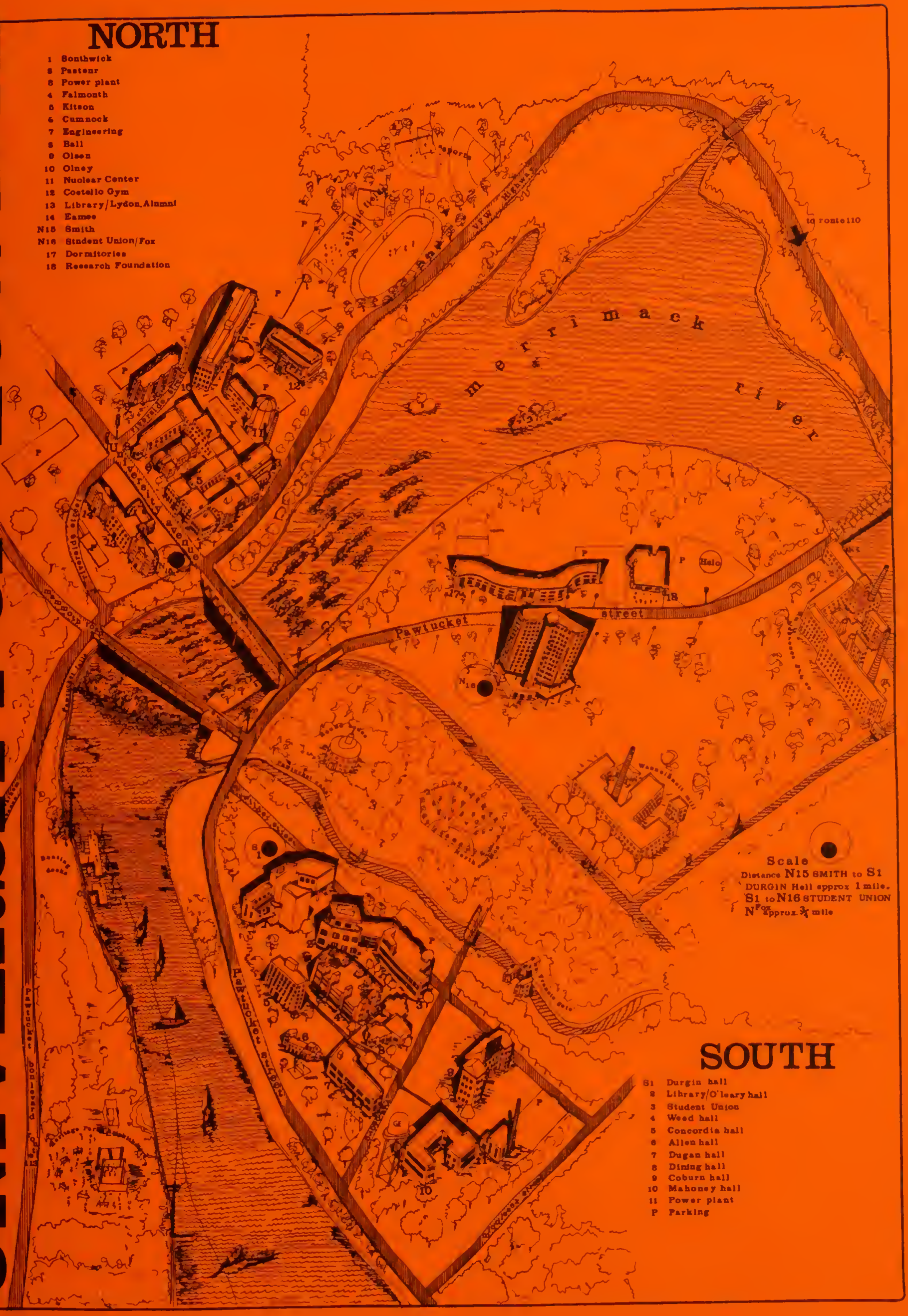

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9	Olsen
10	Olney
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14	Eames
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N16	Student Union/Fox
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18	Research Foundation

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DURGIN Hall approx 1 mile.
S1 to N16 STUDENT UNION
N Fox approx. ¾ mile

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3	Student Union
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